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NEW YORK, APRIL, 1894.

EDITORIAL NOTES.

A CURIOUS remark was made by a railroad man at the last meeting of the New York Railroad Club. One of the speakers had alluded to the fact that the coefficient of friction between the axle and the brass was dependent to a great extent upon the quality of the materials and oil used, and that it had considerable to do with the train which an engine was capable of hauling. The railroad man remarked that "practical railroad men had other things to attend to besides looking after coefficients of friction." It would seem that if there were any one thing that the practical railroad man should make himself familiar with, it is this very thing; and possibly if the man who made the criticism would pay more attention to these trifles his engines would haul longer trains and hot boxes would be of less frequent occurrence.

IF the committee of the Master Car-Builders' Association on Compressed Air and Hydraulic Machinery have any kind of luck, it should be able to present a report full of interest and value to the railroads. During the year that is past THE AMERICAN ENGINEER has devoted considerable space to the description and illustration of hydraulic and pneumatic hoists. In every case where they have been used the report has been one of saving of time and expense. The first cost of a pump or compressor is comparatively little, and the wear upon them, for the service required, almost infinitesimal. An ordinary boiler feed or fire-pump is amply sufficient to maintain a water pressure equal to the demands of shop work, and an ordinary air-brake pump is an excellent compressor. The rest of the expense is for piping, hose, and the construction of the cylinders used as hoists. They save a deal of hard lifting, and cut down the time required for moving heavy weights by a good large ratio.

HIGH-SPEED LOCOMOTIVES.

AT the February meeting of the Western Railway Club, Mr. C. H. Quereau, Engineer of Tests of the Chicago, Burlington & Quincy Railroad, read a very interesting and able paper on Steam Distribution for High Speed Locomotives, which, we regret, is too long for reproduction in our pages. In his introductory remarks he says very justly that "not every one interested in the subject has had opportunities of obtaining the information given by the indicator, or reading indicator cards." To this we will add the statement that it is a matter of constant surprise and regret to editors of newspapers and others that those occupying positions in which there is abundant chance of getting information, so seldom make the best use of such opportunities. Mr. Quereau has availed himself of the information which was within his reach, and has contributed a paper which every locomotive superintendent should read carefully. It is safe to say that, if all who occupy such positions should read and understand it, the companies which employ them would be profited thereby. It is true that there is nothing strikingly new in the paper, but neither are the Scriptures new, and yet the texts contained therein supply the basis of many sermons, some of which are dull and others stimulating. Mr. Quereau's mechanical sermon belongs to the latter class.

The corollary deduced from the discussion is that for fast-running engines there must be ample provision for the steam to get into the cylinders to do its work and get out of them after it has done it, and it is pointed out that it is easier to do this with big wheels than it is with little ones, at the same high speeds.

The author of this paper has adopted the excellent plan of "outlining," in a clear and elementary way, the processes by which he drew his deductions. He gives an explanation of an indicator diagram and what it "indicates," and how the indicated water per H.P. per hour is determined. Now, while there is no doubt many of his readers are more or less familiar with all these general principles, yet it is equally certain that many are not. Those who are can easily skip this part, and those whose minds are rusty will be refreshed, and those who are ignorant will be enlightened.

It is remarkable how rare the faculty is of understanding a subject thoroughly, and then being able to assume the mental attitude of those who are entirely or partially ignorant of it. In an account of the life of the late Professor Tyndall, written by Herbert Spencer, he describes very happily and lucidly this faculty. After referring to Tyndall's wonderful capacity as an "expositor," Spencer says:

"Good exposition implies much constructive imagination. A prerequisite is the forming of true ideas of the mental states of those who are to be taught, and a further prerequisite is the imagining of methods by which, beginning with conceptions they possess, there may be built up in their minds the conceptions they do not possess. Of constructive imagination as displayed in this sphere, *men at large appear to be almost devoid.*" *

The author of the paper before us seems to have this "constructive imagination" in a high degree, or at least to an extent sufficient for the writing of a very clear paper. This is shown in the paragraph on boilers, in which he explains the reasons why high speeds demand a greater steaming capacity than slow speeds. He might have added that the speed of locomotives is always limited by the capacity of the boiler to make steam, hence the maxim which has been laid down, that "*within the limits of weight and space to which it is necessarily confined, a locomotive boiler cannot be too big.*" Or the princi-

* We have italicized these words because they confirm so vividly editorial experience.

ple is more briefly stated in the injunction, always "*make the boiler as big as you can.*"

Regarding balanced valves, the experiments of Mr. Philip Wallis in 1886 are quoted, in which it was shown that there was a saving of 3.8 H.P. by balanced as compared with unbalanced valves.

Of the effect of speed on the average steam pressure in the cylinders, the paper says: "Even though the cut-off and boiler pressure remain the same, this pressure decreases as the speed increases; because of the higher piston speed and more rapid valve travel, the steam has a shorter time in which to enter the cylinders at the higher speed." This is demonstrated with admirable clearness by a series of indicator diagrams, which show that under the same conditions, excepting that the speeds were different, the average pressure in the cylinders varied from 51.5 lbs. per square inch at a speed of 17 miles per hour to 36.3 lbs. at 66 miles per hour. The point of cut-off appears to be about 5½ in. of the stroke. As the author of the paper says: "The resistance of the train and the load increase, and the power of the locomotive decreases with increasing speed, till the resistance and power are equal, when the speed becomes uniform." Now it might seem that the average cylinder pressure could readily be increased by simply admitting steam during a longer period of the stroke; but if we do this with heavy trains and high speeds the boiler will not produce steam enough to supply the cylinders, and the steam will also be used more wastefully if it is expanded less. Attention is called in the paper to the fact that the main difference of the diagrams taken at different speeds "lies in the higher steam lines at the lower speeds"—that is, the steam is maintained during the period of admission at higher pressure at slow than at high speeds. During the latter the steam is "wire-drawn" as it enters the cylinder. One of the purposes of the paper is to show that this wire-drawing may be reduced by the use of larger drivers, Allan valves, increased valve travel, and greater length of steam-ports, and that there will thus be a material increase in the power developed, with a saving of fuel.

These are the recommendations for the steam side of the pistons. Of course the propelling power of a locomotive is represented by the algebraic sum of the positive pressure on the steam side of the pistons and the negative pressure on the exhaust side. The latter is produced by contracted exhaust nozzles, which are necessary if the boiler capacity is small, by excessive lead, which is needed if the engine is overbalanced, and by inside lap or the want of inside clearance. Consequently ample boiler capacity, which will permit of the use of large exhaust nozzles, is recommended, with proper adjustment of lead to reduce compression and inside clearance.

It would be interesting to know to what extent a reduction of compression would be economical, provided there was no momentum of reciprocating weights to be counteracted. There can be no doubt of the fact that all the power required to force the exhaust steam through the exhaust nozzles is waste effort, so far as the action of the steam and pistons is concerned; but an amount of compression just sufficient to fill the steam passages and clearance spaces with steam of boiler pressure is not a waste, but, on the contrary, the late Mr. Hoadley, and, we believe, Professor Thurston have suggested that it might be economical to regulate the power of engines by altering the amount of compression instead of changing the point of cut-off.

The subject of balancing engines is now receiving a great deal of attention, and several schemes are now, or soon will be, before the public, by which the reciprocating parts will be self-balanced. It would be interesting to know to what extent compression should be carried, if the necessity of counteracting the momentum of the reciprocating parts no longer existed.

In this problem of the locomotive, as in most other human affairs, the question of proportion is of the utmost importance. It is true that with large wheels it is easier to maintain the pressure of steam in the cylinders during admission, but large wheels are heavier than small ones—they require larger and heavier cylinders and pistons. All the connections of these, the axles and frames and other parts, must all be larger and heavier; consequently if the wheels of an engine of a given weight are made large and heavy, the boiler must be lighter and smaller, which means contracted nozzles. Obviously there might be more loss from the latter than gain from the use of large wheels. There is doubtless some relation between the size of the wheels and size of the boiler which will give the best attainable results. This proportion is the problem which designers of locomotives have to work out.

The conclusions that Mr. Quereau has drawn are, that for fast-running the wheels and boiler should be big and the steam pressure high, which in a certain sense are contradictory conditions, because the bigger the wheels the smaller the boiler must be with an engine of a given weight, and the higher the pressure the greater the weight, and consequently the smaller the size of the boiler. The problem, then, is to so proportion these organs and functions as to get the best results.

Considering the importance which is assigned to the maintenance of a high steam pressure during admission, and reducing the back pressure on the exhaust side of pistons, it is remarkable that some of the old or modified forms of old valve gear, with separate cut-off valves, have not been revived. In some of these the exhaust was controlled by the main or lower valve, which had a constant travel, and the admission was governed by an upper or cut-off valve, with a variable throw. Thomas Winans, of Baltimore, constructed a valve gear of this kind, which was applied to an engine called the *Centipede*, which was built about the year 1855 or 1856. The engine had eight wheels coupled of 42 or 43 in. diameter, and a four-wheeled truck in front. The front end of the engine rested on a roller in the center of the truck, so that the truck could move laterally in relation to the engine. This, it is thought, was the first use of a lateral moving truck under locomotives. The valve gear consisted of a lower main valve which was worked by a forward and a back-motion hook. On top of this was a sort of gridiron-valve with two or three admission ports for each end of the cylinder. It was worked by an ordinary link. With this gear the steam-ports could be opened wide at 2 or 3 in. of the stroke, and varied for each point up to full stroke, and in each case gave a full port opening. The lower valve controlled the exhaust, and having a constant travel for all points of cut-off, there was a very small amount of back pressure. This engine was operated on the Baltimore & Ohio Railroad for a number of years. The valve gear gave the most perfect theoretical movement of any locomotive gear the writer has ever seen, but the valves were large, and gave trouble from cutting. A balanced arrangement was put on them, but it is thought was never satisfactory. Possibly with some of the present approved methods of balancing valves such a device might be made successful.

Another peculiarity of the engine was that the cab was in front. The boiler was the same as those used on the famous "camel" engines of that date, excepting that it was somewhat longer.

NEW PUBLICATIONS.

THE "PRACTICAL ENGINEER" POCKET-BOOK AND DIARY, 1894. 227 pp., 5¼ × 3¼ in. Edited by W. H. Fowler. Technical Publishing Company, Manchester, England.

This class of books always cause a reviewer dismay. The difficulty of doing them justice is somewhat like that which would be encountered in reviewing a dictionary. The book

before us is edited by the editor of the *Practical Engineer*, a newspaper published in Manchester, England. It begins with some explanations relating to mensuration, which are followed by an excellent table of decimal equivalents of sixty-fourths, which is followed by a table of polygons giving their names and various dimensions. Perhaps most of our educated readers think they know the names of various polygons, yet probably it will be new information to many of them that a twenty-sided figure is an "eicosagon."

After the usual tables found in such books there is a division devoted to Steam Boilers, which occupies 44 pp. and gives a great deal of interesting and useful information. This is followed by The Steam-Engine, 66 pp.; Transmission of Power, 23 pp.; Hydraulic Engineering, 10 pp. This is followed by miscellaneous data about a variety of subjects, and is succeeded by divisions on Gas and Oil-engines, 16 pp. The book concludes with notes on patents and a diary and blank pages for memoranda. The book is of convenient form and size for pocket use, and is strong on the subjects of boilers, steam, gas and oil-engines.

A Practical Treatise on the Steam Engine. Second Edition. By Arthur Rigg. Spon & Chamberlain, New York. 379 pp., letter-press, 10¼ × 8¼ in., 103 plates.

Those readers who are not acquainted with the first edition of this book are ignorant of one of the best treatises on the subject in the English language. The general scheme of the book is indicated by the observations in the preface, in which the author says: "Strange it seems that in our own country there still lingers among many clever practical men a profound distrust for theory, while in foreign countries engineers are too apt to depreciate practical experience. One view is the legacy of ignorance, the other the pride of intellect; and both are equally pernicious."

On this postulate the author has constructed his treatise, which, he says, was "written to describe various examples of Fixed steam-engines, without entering into the wide domain of Locomotive or Marine practice; to give details of construction, with the principles by which their relative proportions may be calculated, and to investigate the more modern applications of science to the subject. In order to avoid mathematical forms of expression, which are unfamiliar to practical men, the graphic method of calculation is brought into prominent use, and it will be found that with very little attention a busy engineer can adapt this system to ordinary calculations, for it has the merit of extreme simplicity, and can be employed even when more elaborate systems fail."

The difference in the size of the two editions is indicated by the fact that the first had 312 pp. of letter-press, and the new one has 379. The number of plates in the old one was 94, whereas the last has 103. There are 24 chapters on the following subjects: Systems of Measurement; Matter, Force and Motion; The Horizontal Steam-Engine; Cylinder, Piston and Piston-Rod; The Slide-Valve (Theoretical Investigations); Slide-Valves (Construction); Lubrication and Lubricators; Connecting-Rods; The Cross-Head or Motion Block; Parallel Motions; Cranks and Eccentrics; Influence of Cranks and Connecting Rods; Shafts, Keys and Hammers; Pedestals and Wall-Boxes; The Fly-Wheel; Steam-Engine Governors; Condensers for Steam-Engines; Spanners and Nuts; Steam-Engine Indicator; Steam-Engine Indicator Diagrams; Influence of the Velocity of Reciprocating Parts of Steam-Engines; Description of Illustrations; Modern High-Speed Steam-Engines; Heat and Steam.

The most noteworthy portion of this book is the part relating to the influence of the velocity of reciprocating parts of steam-engines. A preliminary chapter elucidates very clearly the laws which govern matter in its various forms and motions. Probably there are very few engineers who could succesfully pass a rigid examination on these subjects, or who have a perfectly clear understanding of them. The author of the book before us has given his readers an admirably clear chapter which is not hard reading, and which requires only a knowledge of elementary algebra to understand it. Another chapter, on the Influence of Cranks and Connecting-Rods, contains an admirably clear, graphical elucidation of this somewhat intricate subject. These two chapters, in connection with the one on the influence of the velocity of the reciprocating parts, are, perhaps, the most satisfactory and conclusive dissertation on the subject that has ever been written, and no student or engineer interested in the construction of the steam-engine should be ignorant of this general subject, which Mr. Rigg has explained so clearly. The other portions of the book can also be commended very highly, and this and Holmes's "Treatise on the Steam-Engine" are the books which it is always safe to advise students, mechanics and engineers to study.

The type, paper and printing are all good. The only criticism required that is unfavorable is with reference to some of the engravings. Some of these are much worn, and should have been re-engraved for the new edition. Reference may be made to fig. 108 and figs. 196–222, which are unworthy, and should be condemned and replaced by new ones.

Locomotive Mechanism and Engineering. By H. C. Reagan, Jr., Locomotive Engineer. 296 pp., 7½ × 5 in. John Wiley & Sons, New York.

This book belongs to the class which are called "practical," and has some of the characteristics of that kind of literature. It has never been quite obvious why an author, when he undertakes to write anything "practical," omits the definite and indefinite articles. They often do so, however, and such books are generally written in what may be called railroad English. As an example of this, the following opening sentence of our author's second chapter is quoted, the words which he has omitted being printed in brackets. He says: "The steam-pipes in [the] smoke-arch are connected to the end of [the] steam or dry-pipe, which is called [the] bulkhead or tee-pipe, and [is] joined to [the] steam passage in [the] saddle, as in fig. 5." Just why it should make writing appear to be more "practical" to omit some of the words which every man would use in conversation is not clear, but such omission is very common in the literature written for and by railroad men. This, however, is a minor defect in a book which has very much to recommend it.

Another peculiarity of what are called practical books is that authors of such literature do not seem to aim at strict accuracy or lucidity in their statements. This is often a serious defect. As examples of this we may quote from the first chapter on the locomotive boiler, which gives a very brief and incomplete description of its construction. It is said, for example, that "the Belpaire boiler uses *radial* stays." As a matter of fact, in nearly all Belpaire boilers, and in the one represented in the author's engraving, the stay-bolts are not radial, but are parallel to each other, the plates being flat. He also says "the mud cannot accumulate on the crown-sheet as it does when using crown-bars." This is hardly true—it can accumulate there as easily in one boiler as in the other, the only difference being that it can be removed easier from the Belpaire crown-sheet than it can be from one covered with crown-bars. He also says that "the sheets (of a Belpaire boiler) can adjust themselves to each other better under different pressures and change of temperature." It is not quite clear what this means. He probably has in his mind the fact that the flat top plates of a Belpaire fire-box have more flexibility than curved plates would have, and they can thus distribute the strains due to the steam pressure, which they must resist, more uniformly on the stay-bolts than it would be distributed if the plates are curved.

The different chapters of the book are on the following subjects: The Locomotive Boiler; Front End, or Smoke-Arch; Steam Cylinders and Connections; Locomotive Frames, Driving-Boxes, and Spring Rigging; Rods and Connections; Breaking of Rods; Valve Motion; Valve Setting; The Compound Locomotive; Indicator Cards; Descriptions of Various Systems of Compound Locomotives; Injectors, Safety-Valves, Steam Gauges, etc.; Brakes, Air-Pumps, Valves, Pump Governors, and Westinghouse Brakes.

The general plan of the book is to give a brief description of the part treated of in each chapter, and then give a series of questions and answers by which the construction, operation, and management of these parts are described. The descriptions have more of the character which an engineer or fireman who seeks information about the running of engines would demand than elucidations of the principles or methods of construction of locomotives. The descriptions are very good of their kind, and are full of suggestions—some of them novel—which will be of very great assistance to those who have or expect to have the care of locomotives.

A considerable portion of the book is devoted to compound locomotives, and the principles and details of construction of the chief types which have been built in this country are described. The author has also given directions for the management and running of compound locomotives and hints of various kinds, telling what should be done in cases of accident with such engines, which will no doubt be read and studied with great interest, not only by engineers and firemen, but by master mechanics as well.

The typography and about half the engravings are very good. The questions and answers would, however, be pleasanter to read, and easier understood, if they were respectively printed in different type. As they are now, it is not always

clear whether one is reading the question or the reply to it. A considerable number of the engravings are poor "process" copies of good original illustrations. Many of the illustrations in the chapter on brakes are of this kind, and are execrable; and as they represent complicated structures, will be incomprehensible to most readers. The engraving on p. 109 of the combined cylinder-cock and starting-valve for Vauclain compound engine, is made from a very bad free-hand drawing, and looks as though it represented the entrails of some extinct animal.

Notwithstanding these defects, the book can be recommended to the class of readers for whom it was intended. There is an incisive style about it which impresses the lessons taught, and sometimes makes things clear which perhaps would be less apparent if described more elaborately. The author says in his preface that he "has illustrated the principal 'breakdowns' that happen to a locomotive, so that when one actually occurs on the road the engineer can compare the break with the illustrations in the book, and find out exactly what should be done." This statement gives the key-note to the book.

TRADE CATALOGUES.

HORIZONTAL WATER-WHEEL. Built by the Swain Turbine & Manufacturing Company, Lowell, Mass. This Company has issued a sheet giving an excellent engraving of one of their water-wheels, with a statement of its advantages, a table giving the diameter of wheels, amount of water used, revolutions per minute, and H.P. of wheels with from 6 ft. to 50 ft. fall. A list of parties using these wheels is also given.

DESCRIPTIVE CIRCULAR AND PRICE-LIST OF CENTRIFUGAL PUMPING MACHINERY. 8 pp., 6 × 8¼ in. Morris Machine Works, Baldwinsville, N. Y. This publication is what its name implies, a descriptive circular and price-list, which is illustrated by good engravings of various kinds of centrifugal pumps, but which have not had justice done to them in the printing. Some details of the pumps are also illustrated.

THE AMERICAN FUEL ECONOMIZER, *for Heating and Purifying Feed-Water for Steam Boilers by Utilizing the Heat in the Flue Gases.* The American Fuel Economizer & Engineering Company, No. 136 Liberty Street, New York. 38 pp., 8 × 11¼ in.

This is a beautifully printed pamphlet, with excellent paper, typography and engravings, but is one of the most provokingly incomprehensible publications that has come to hand recently.

GLOBE SPECIAL CASTINGS FOR WATER-WORKS. Builders' Iron Foundry, Providence, R. I. 48 pp., 3½ × 5½ in. This is a new edition of a catalogue which was noticed some months ago in these columns. It includes "globe-specials, reducers, crosses, curved pipe, bends, elbows, split sleeves, offsets, plugs, caps, gate-boxes, strainers, flange, and straight cast-iron pipe." The latter part of the book contains a somewhat more extended notice of the Venturi meter than was given in the previous edition of this publication. A table giving the thickness of metal and weight per length of cast-iron pipe adds to its usefulness.

ILLUSTRATED CATALOGUE OF LATHES AND OTHER MACHINE TOOLS. Manufactured by F. E. Reed & Co., Worcester, Mass. 47 pp., 6 × 9 in.

This catalogue is made in accordance with the dimensions recommended by the Society of Mechanical Engineers for a standard size, and is one of the earliest examples of conformity to that recommendation.

The lathes illustrated are mostly of the lighter varieties, which are well illustrated with excellent wood-cuts and described in considerable detail. The largest lathe illustrated is one of 30-in. swing and bed 12 ft. long, the smallest 9-in. swing and 3½ ft. bed. A number of sizes, from 16-in. to 30-in. swing turret head-lathes, are also illustrated and described. A variety of appliances for use in connection with the different lathes is also shown. On the last page No. 1 and No. 2 milling machines are illustrated.

The catalogue is well printed and has a paper cover, which is mounted on cloth—an excellent provision to prevent its destruction.

THE CHARTER GAS-ENGINE. Manufactured by the Charter Gas-Engine Company, Sterling, Ill. 32 pp., 5 × 7¾ in. This pamphlet gives chiefly letters of recommendation from users of this engine. The latter part of the book contains an imperfect description of the engine, but it is without any illustrations, and is incomprehensible to persons who are ignorant of the principles and construction of such machines. The usefulness of the publication would be immensely increased if the publishers would give a lucid description, with suitable sectional engravings, describing the principles, construction, and operation of their engine. An excellent engraving showing an external perspective view of one of these engines is given on the outside cover, but it does not show to advantage, as the cover is a dark red color.

HINCKLEY AUTOMATIC BRAKE-SLACK ADJUSTER, *for Automatically taking up the Slack in Brake-Rigging due to Wear of Brake-Shoes and Pins, Stretch of Rods, etc.* 6 × 11¼ in., 26 pp. The Hinckley Brake Company, Trenton, N. J.

This pamphlet describes the various appliances made by this Company for taking up the slack of brake-shoes and levers. These appliances are illustrated by very good engravings, most of them made from outline drawings, which show the construction clearly. A folded plate at the end of the book shows graphically the operation of these adjusters. The Company also send some sheets with directions for applying the adjusters to different kinds of brake apparatus. It is thought that it would be an advantage if the Company would describe more fully the elementary principles and the construction of their devices in their catalogues. It should be remembered by those who publish such literature that most of those who receive it are absolutely ignorant of the object and purpose of the appliances described, and do not know how it is constructed or the principles of its operation. The "wayfaring men" should always be kept in mind in writing such descriptive catalogues, and it should also be remembered that many of them are closely akin to fools in the characteristic that they are ignorant of the subject described.

GRAPHITE AS A LUBRICANT, *Scientifically and Practically Considered; also its Value as an Accessory for Engineers and Machinists.* Joseph Dixon Crucible Company, Jersey City, N. J. 16 pp., 5⅝ × 7 in. This little pamphlet contains accounts of various experiments and uses to which graphite has been put for lubricating purposes, with testimonials from various practical and impractical engineers. On the first page of the book is the following paragraph, to which we and probably some of our readers would like to add an interrogation mark. The paragraph referred to is the following:

"The difference between a perfectly pure graphite and one almost pure, but still totally unfit for lubricating, cannot be detected by either sight or touch; the buyer's only guarantee of the purity is the name and reputation of a responsible manufacturer."

Now what we would like to know, and probably some of the readers of this pamphlet will be disposed to join us in our "quest," is how do the manufacturers know whether the graphite "is perfectly pure"? If you can't see nor feel whether it is pure, how can it be known that it is pure? In other words, the buyers and users of graphite would like to know how it can be tested to know whether it is pure or not.

The latter part of the pamphlet contains observations on the nature, peculiarities, lubricating qualities, and description of the uses of graphite as a lubricator.

CATALOGUE OF TESTING MACHINES, Manufactured by Tinius Olsen & Co., Philadelphia, Pa. 42 pp., 10½ × 8½ in.

We have called attention a number of times in these pages to the fact that on many subjects trade catalogues supply the best literature that is obtainable. The publication before us is an example of that kind. The reader who has a general and perhaps vague idea of the design, construction and use of testing machines and takes up the catalogue of Messrs. Olsen & Co. will probably be surprised to find how much the subject to which it relates has been developed beyond his knowledge of it. No less than 39 different machines and instruments for testing various kinds of materials are illustrated by engravings, each of which represents only one of a class, of which there are usually a number of sizes, with different dimensions and capacities. Thus the engraving of the first machine illustrated represents six different machines of 50,000, 100,000, 150,000, 200,000, 300,000, and 400,000 lbs. capacity. The others represent from one to half a dozen different sizes of machines, so that somewhere about 200 different machines and

instruments are described in the catalogue, and are made by this firm. The extent to which such machines are now used will also be a surprise to many readers. On p. 4 is a list of firms and companies which are supplied with the Olsen machines. This includes one of 400,000 lbs. capacity, furnished to the Johnson Company, of Johnstown, Pa., two of 300,000 lbs. capacity, 15 of 200,000 lbs., 34 of 100,000 lbs., 20 of 50,000 lbs., eight of 40,000 lbs., four of 30,000 lbs., two of 20,000 lbs., and 14 of 15,000 lbs., or 100 machines which are now in constant use in the works and laboratories of various manufacturing establishments and educational institutions. This includes only one class of machines. Other lists of other kinds in use include the names of no less than 102 different firms, companies and institutions, which have been supplied with appliances of this kind by this firm, showing how very general the practice now is of making systematic and scientific tests of materials used in various kinds of structures and supplied for different purposes.

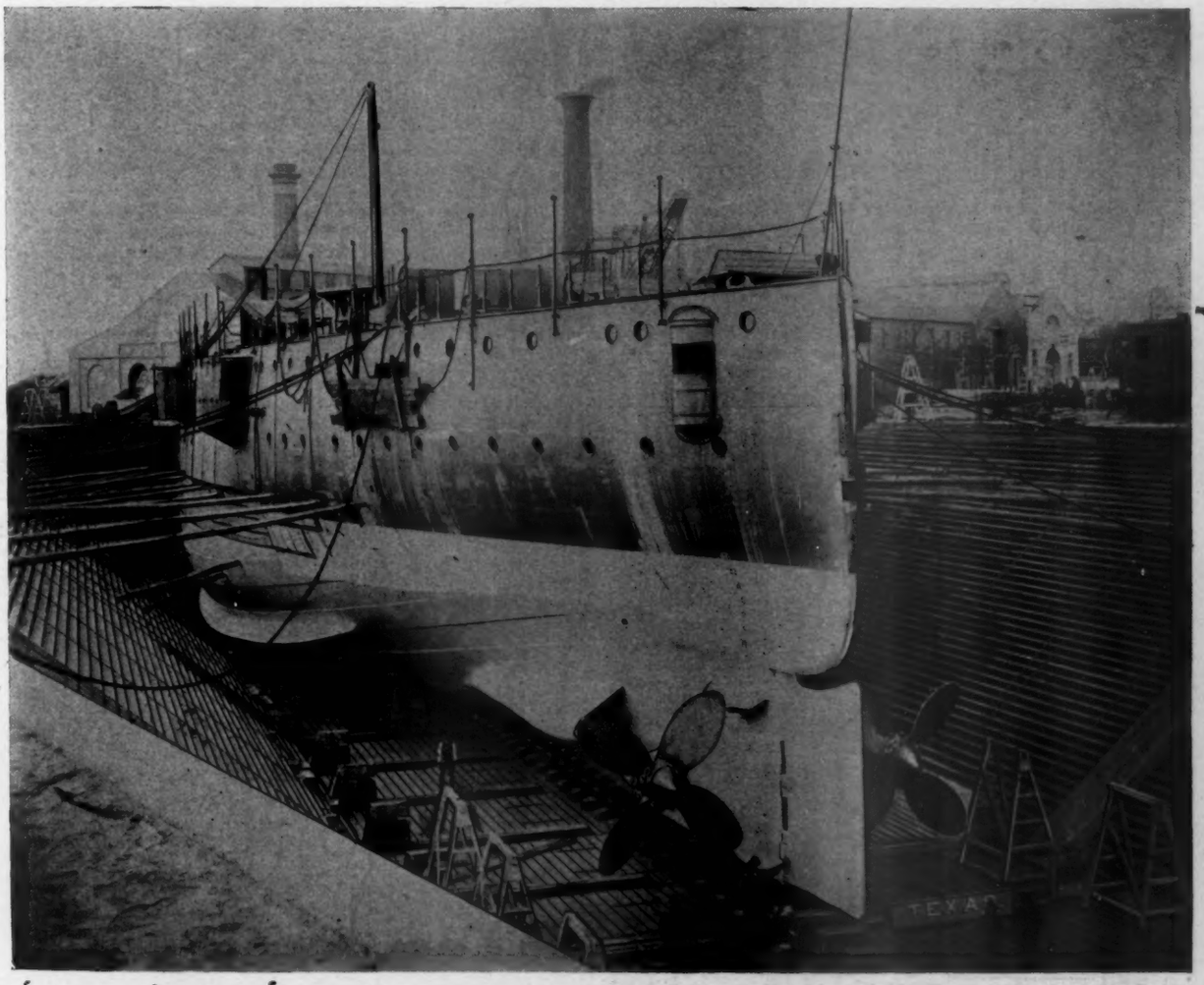
The catalogue includes not only machines for determining tensile and compressive strength of metals and other materials, but special machines for testing wire band iron and springs, for subjecting materials to impact, transverse and torsional strains for testing chains, bridge building material, cement, textile materials, yarn, thread and oil. The catalogue gives an excellent idea of the various uses in which testing machines are now employed, and the extent to which they are used. The engravings, with the exception of the first one, which represents this firm's exhibit in the Columbian Exhibition, are all excellent wood-engravings. The one referred to is hardly up to the standard of the rest.

The latter part of the book contains some folded plates, one of them showing a new machine, for structural material, having a capacity of 200,000, 300,000, or 400,000 lbs. Another folded sheet gives engravings and a description of a new automatic and autographic machine. The last plate is an outline engraving of one of these machines, with a full description of it. There are also directions for operating testing machines. The usefulness of the book would be increased if a short elementary treatise was given on the construction of testing machines, and if the methods and object of such tests was described, so that a novice could go to it for information.

THE LAST OF THE LOCOMOTIVE PROBLEM.

Editor of THE AMERICAN ENGINEER:

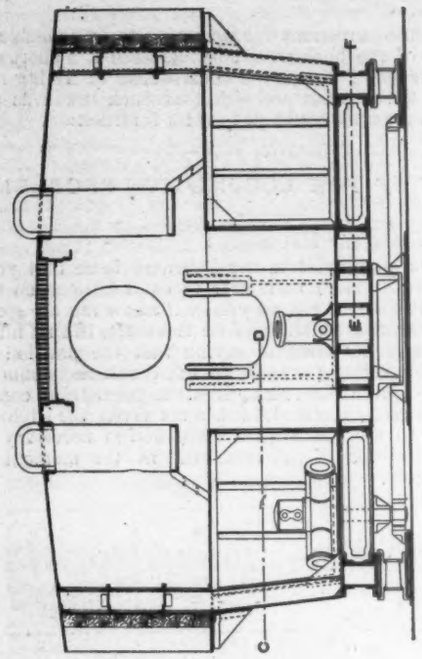
Although you announced in the February issue that your columns would be closed thereafter to contributions on the "Locomotive Problem," I hope you will allow me the space to point out that although M. René de Saussure, in that number, acknowledges his error in saying that the position of maximum piston velocity was when the crank and connecting-rod were at right angles, and gives the geometrical conditions which are to be satisfied, he has not given the slightest information as to the geometrical construction necessary to determine the position of the cross-head at the moment of maximum velocity.

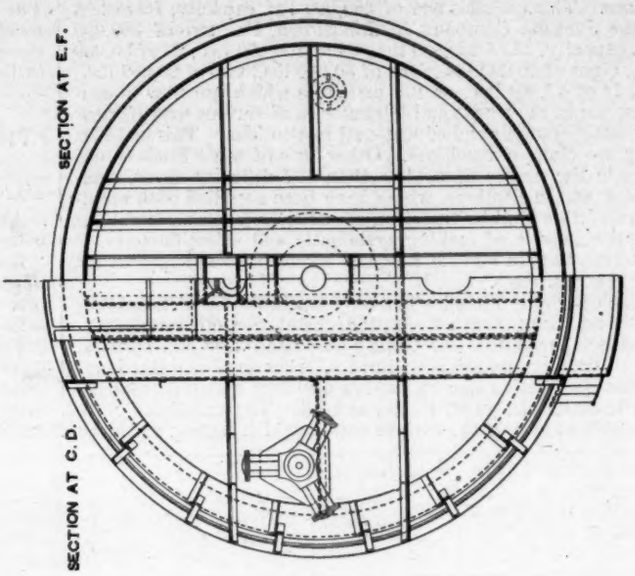


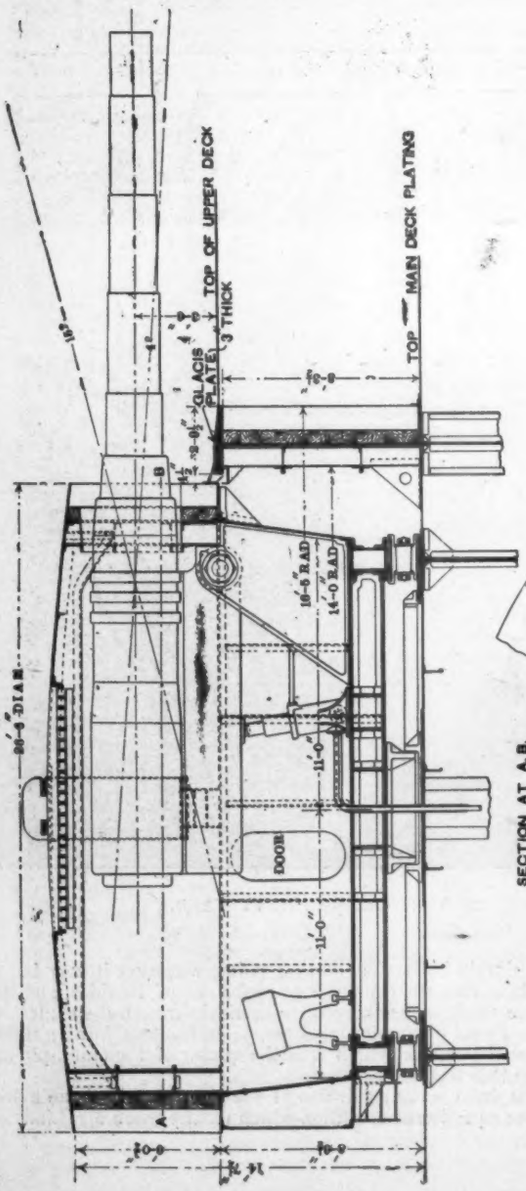
UNITED STATES BATTLESHIP "TEXAS" IN DRY DOCK AT NORFOLK, VA., NAVY YARD.

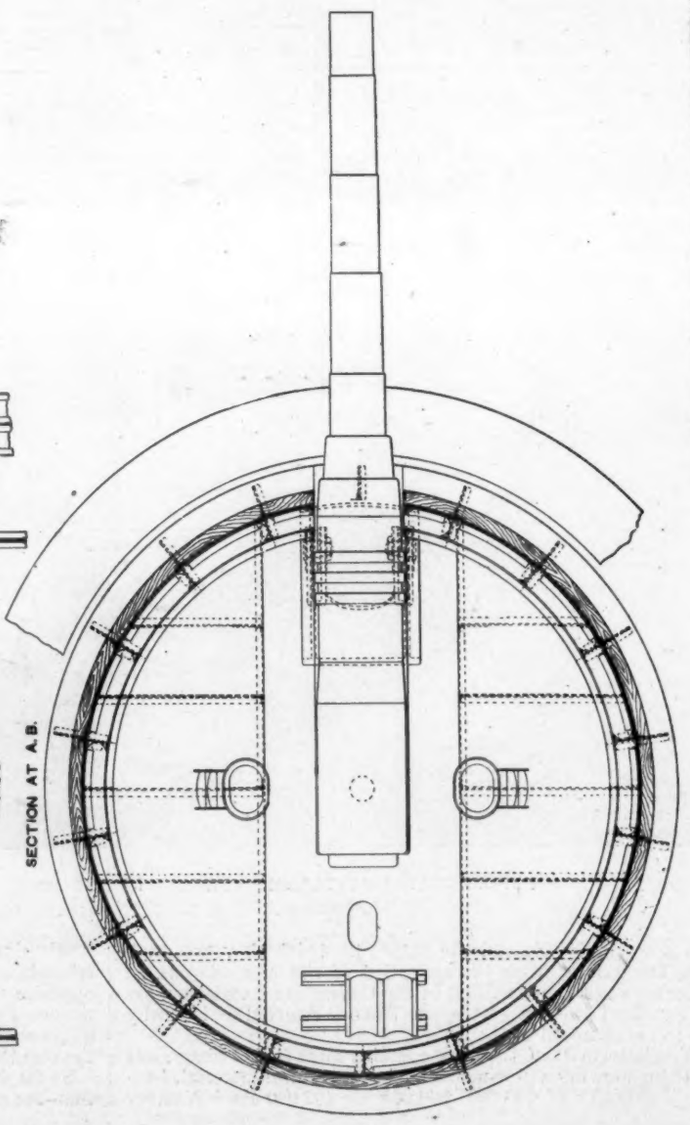
We simply know that at that point, wherever it may be, a triangle having the connecting-rod for one of its sides, and its opposite angle somewhere on a vertical through the center of the cross-head pin (which is, of course, unlocated), forms a right angle at that angle which is at the center of the crank-pin at the required instant.

So far from being a solution of the question, this is no more than the equation of condition which results when Mr. Linden-



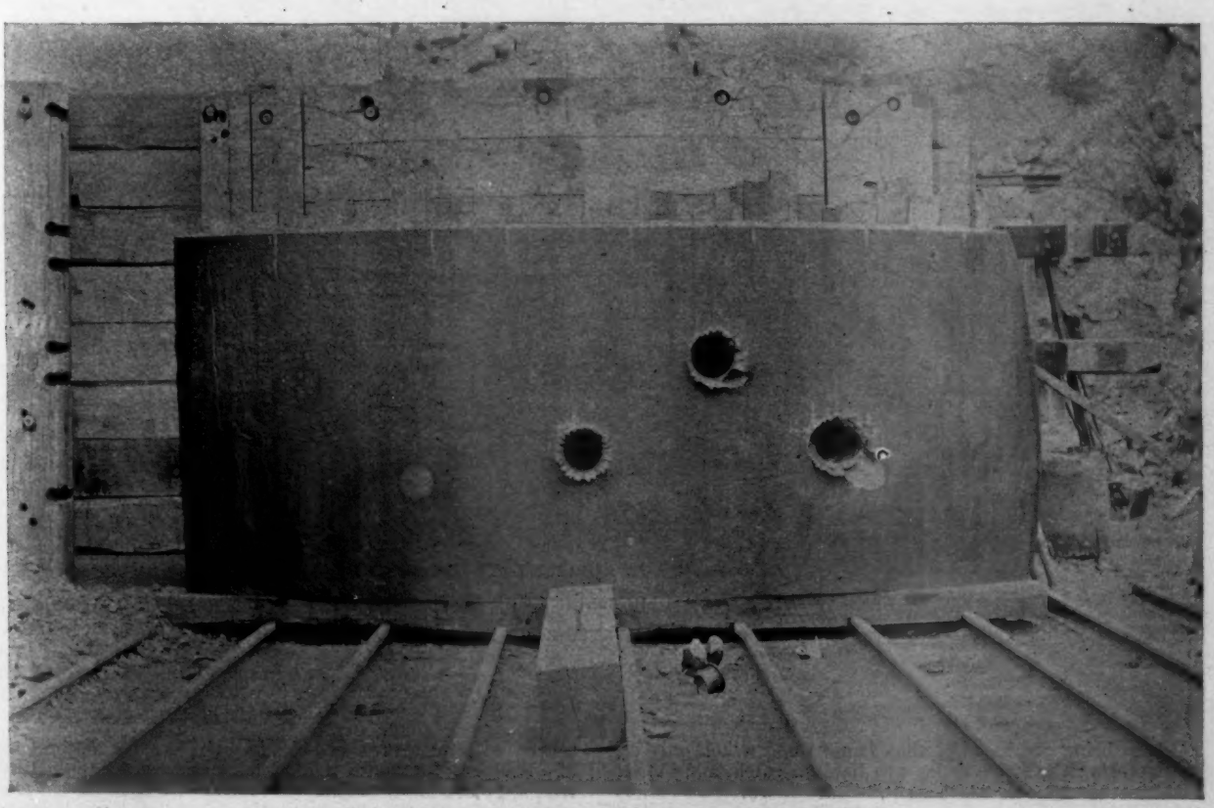






TURRET OF UNITED STATES BATTLESHIP "TEXAS."

TEST PLATE OF REDOUBT ARMOR UNITED STATES BATTLESHIP "TEXAS."



TEST PLATE OF TURRET ARMOR UNITED STATES BATTLESHIP "TEXAS."

berger puts his second differential coefficient equal to zero; and is considerably harder to solve, since there are known methods of solving all cubic equations, I believe, while this problem requires a special solution to be worked up for this individual case, which is by no means an easy matter.

It is possible, I know, for I saw some years ago in the London *Engineering* a geometrical solution which, I think, was said to have originated with Professor Rankine, but my recollection is that it was quite long and difficult, so that by the time the result is reached the balance of simplicity is on the side of the analytical method; while the geometrical method has the further disadvantage that, on a sheet of paper of any reasonable dimensions, the desired angle could not be obtained to less than two or three minutes of arc, and the cross-head position not located to more than two places of decimals in inches. I believe that this problem has no practically useful application, and therefore when we want a solution of it we want one which is satisfactorily accurate, as Mr. Lindenberger's is. This being the case, with all due respect for M. de Saussure's geometrical solution, as far as it goes, one cannot help being reminded of that famous colt which only had two defects: the first was he was hard to catch, and the second was that after he was caught, he wasn't worth a —— anything.

J. Esrey Johnson, Jr., M.E.

Syracuse, N. Y.

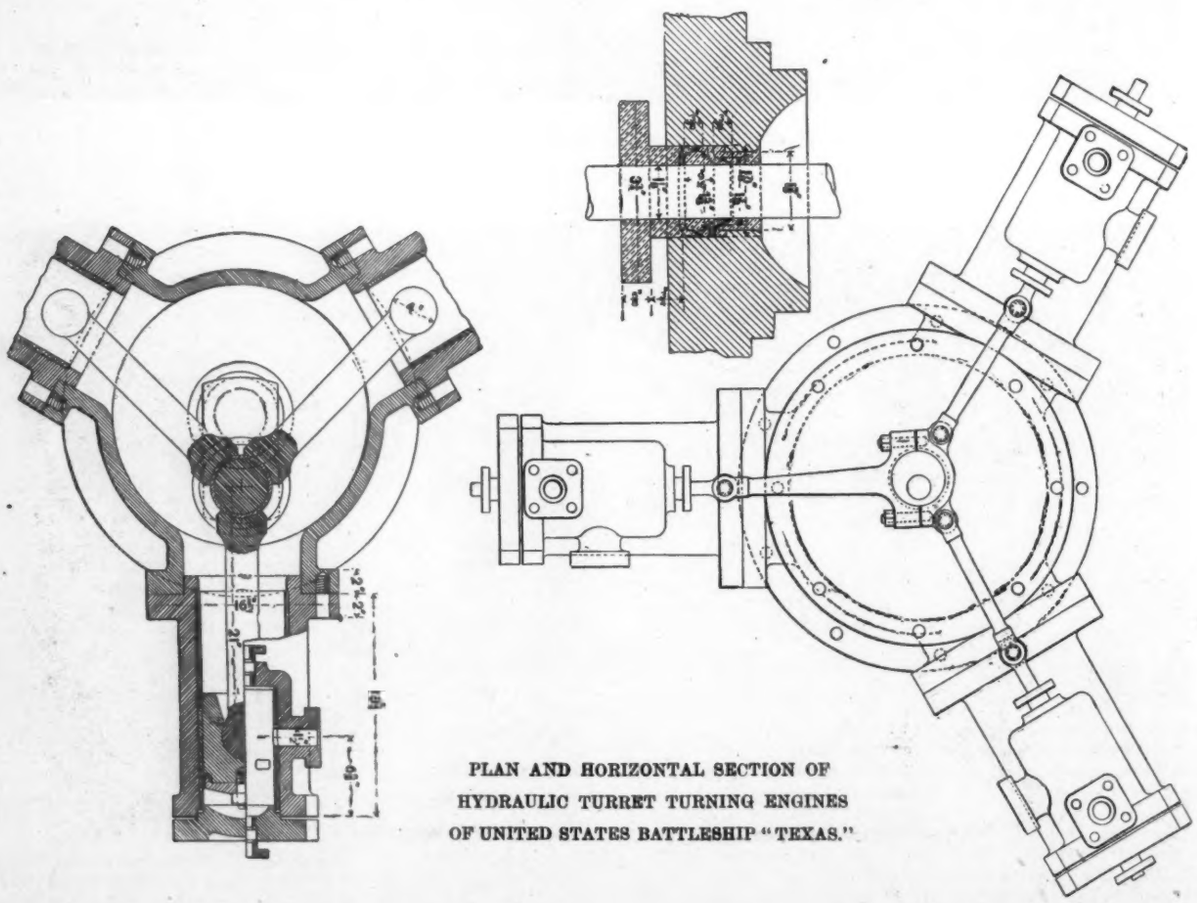
TURRET AND TURRET-MOVING MACHINERY OF THE UNITED STATES BATTLESHIP "TEXAS."

In our last issue we published a general description of the United States battleship *Texas*, accompanied by illustrations of the vessel itself. Through the courtesy of the officials of the Navy Department and the contractors for the parts furnished, we are now enabled to give a very complete set of illustrations, showing the method of construction adopted in the building of the turrets and the mechanism employed in their operation. A reference to the deck plan of the ship, published in the March issue, shows that the turrets are located *en échelon* with the forward turret on the port side, and that the two are embraced within a redoubt armor that extends diagonally across the vessel protecting the machinery.

The armor for the ship is all of nickel steel not Harveyized, and has been manufactured by the Bethlehem Iron Company, of South Bethlehem, Pa. The half-tone photo-engraving of this armor, with the three shot-holes in each plate, is a reproduction of a photograph taken of the test plate selected for the ballistic trial for acceptance. It may be remarked that in the selection of the trial plate the Government representative and inspector invariably selects what appears to him to be the poorest of the

TEST OF REDOUBT ARMOR.

Shot No.	Gun Used.	Projectiles. Kind.	Projectiles. Weight.	Striking Velocity. Ft. per Second.	Energy in Foot Tons.	Penetration.	Remarks.
1	8-in. Breech-Loading Rifle.....	Holtzer	250 lbs.	1,678	4,885.7	14 in.	No Cracks.
2	" " "	"	250 "	2,006	6,982.4	Perforated.	" "
3	" " "	"	250 "	1,835	5,842.8	15½ in.	" "
Total	....	.....	... .	.....	17,710.9	.....	.....



PLAN AND HORIZONTAL SECTION OF HYDRAULIC TURRET TURNING ENGINES OF UNITED STATES BATTLESHIP "TEXAS."

lot that has been offered for acceptance. It was of nickel steel, measuring 16 ft. 6 in. by 8 ft. 4 in., with a thickness of 12 in. and weighing 69,128 lbs. The test was made at the proving grounds of the Bethlehem Iron Company, at Redington, Pa., on March 22, 1893, with the results given in the table on the previous page.

The test resulted in the acceptance of the group of plates, and is noticeable for the entire absence of cracking.

Referring now to the full-page engraving of the turret, the construction is at once apparent. The redoubt armor extends from the top of the main deck plating for a height of 8 ft. 3½ in. to the top of the upper deck. Its sides are parallel to each other, and it has a uniform thickness of 12 in., with a backing of wood 6 in. thick. The wood is in turn held by a heavy plate framing strengthened by horizontal plates kept in position by angle irons. The whole is capped by a glacis plate 3 in. thick, and so tapered off on the outer edge that in case it is struck by a shot, the latter will glance and strike the armor of the turret. The turrets are 26 ft. 6 in. outside diameter, and the armor plates are bent at Bethlehem to conform thereto. The photo-engraving of the test plate of the turret armor gives a good idea of its general appearance after the trial. Like that of the redoubt armor already referred to, this plate secured the acceptance of the turret plates. It is a nickel steel plate measuring 15 ft. 7 in. × 6 ft. 2 in. with a thickness of 12 in and weighing 48,400 lbs. It was tested at the Redington proving grounds of the Bethlehem Iron Company on May 31, 1893, with the results given in the accompanying table:

BALLISTIC TEST OF TURRET ARMOR, UNITED STATES BATTLESHIP "TEXAS."

Shot No.	Gun Used.	Projectiles.		Striking Velocity. Feet per Second.	Energy. Foot Tons.	Penetration.	Remarks.
		Kind.	Weight.				
1	8-in Breech-Loading Rifle.....	Holtzer	250 lbs.	1,576	4,304.4	11⅛ in.	No Cracks.
2	" " "	"	250 "	1,826	5,776.8	15 "	" "
3	" " "	"	250 "	2,004	6,958.8	Perforated.	" "
Total	.....	.....	.....	....	17,041.0	.....	.....

The remarkable results obtained are such that the manufacturers are to be congratulated upon the high grade of the plates turned out. It will be interesting here to call attention to the methods pursued at South Bethlehem in the making of these exceedingly heavy plates. In the first place, all of the machinery and the whole plant employed had to be designed and constructed from the very foundations, and this will form a lasting monument to the memory of Mr. John Fritz as the last notable engineering feat of his career. The specifications of the Navy Department require that the ingot shall weigh at least twice as much as the finished plate, in order that perfectly sound and solid metal may be secured, and all pipings be cut off in the ample shrink head that has been allowed. The steel is melted in open-hearth furnaces, and drawn out into ladles having capacities of from 40,000 to 90,000 lbs. each. These ladles are mounted upon trucks that travel over rails laid along each side of the casting pit. The ingot molds are set up in this pit, and in casting the larger ingots, the contents of several ladles, each consisting of the charge of one furnace, are poured into one mold. Thus an ingot weighing 110 tons can readily be cast. After an ingot has been allowed to cool in its mold for several days it is taken, while still hot, to the great 125-ton hammer or 14,000-ton press and forged down to the proper thickness, that portion of the ingot which was cast at the bottom forming the body of the plate.

In the case of plates tapering in section, the taper is usually formed in forging. The faces of the plates are completed in this operation—that is, they are not as a rule subsequently machined, but are used black as they leave the hammer or press, except that some of the scale is removed by chipping. When the plate is forged to the required thickness, and somewhat full of width, a large amount of metal from the top of the ingot and a small amount from the bottom is cut off at the hammer or press. The plates are then annealed. After annealing, test specimens are taken from each end of plates to determine the physical qualities of the steel in its natural or annealed condition, and chemical analyses are made. If tests are satisfactory, the plates are then ready for preliminary machining.

As already stated, the flat faces are, as a rule, not machined. It is unnecessary, because the front side, which is exposed to the impact of the shot, should possess all the surface hardness and toughness resulting from forging, and because any slight unevenness on the back side can be taken care of by bedding the plate into its wooden backing, to which it is drawn by holding bolts.

The preliminary machining consists in trimming the plates on their longer edges to somewhat full of their finished width, and in beveling or rounding the edges if required. This work is done with cold saws, planers and milling machines. The metal is left on ends of plates for further testing. After the first machining the plates are sent to the 7,000-ton bending press to be bent or curved as per templates; they are then ready for tempering.

The operation of tempering requires a powerful crane, large heating furnaces and a great tank of oil. Its object is to toughen the steel and give to it the proper hardness, and it calls for much experience and skill.

After tempering further test specimens are cut from the ends of the plates in order to determine the physical qualities resulting from the treatment. If the qualities are satisfactory, the plates are ready for the ballistic test, and a plate for this purpose is chosen from the lot or group by the Naval Inspector. If the ballistic test is successful, the lot or group which it represents is ready for finishing.

The finishing consists in "rectifying"—that is, slightly bending at the press to bring the plates as nearly as possible to the shape of the templates, and in accurately machining all the edges to required dimensions.

The last operation is the drilling and tapping of the bolt-holes in back of plates, for the bolts which hold the plates in position on the ship. These bolts vary in diameter from 1.5 in. to 3 6 in., according to the thickness of the plate, and are spaced about 2 ft. apart each way, or one every 4 ft. of surface. From the above description, it will be seen that the whole manufacture is one requiring great care and a thorough knowledge of conditions both chemical and physical at every step, and the wonderful results of the ballastic tests already referred to, where several 8-in. shots striking with an energy of nearly 7,000 foot-tons fail to develop any cracks, indicate to what perfection the production of this material has been brought.

Returning now to the engraving of the turret after this digression, we find that it is protected by 12-in. armor backed by 6 in. of wood and covered with a 1¼ in. plate. The armament of each turret consists of one 12-in. breech-loading rifle, which is given the proper elevation for firing by the hydraulic lift shown in the vertical section of the turret at the upper left-hand corner of the engraving.

That portion of the turret which comes back of the redoubt armor is constructed of shape irons and has the form of an inverted truncated cone. Starting in with a diameter of 24 ft. 6 in. just back of the wooden backing of the armor, it tapers down to a diameter of 22 ft. at the floor-line. The main floor framing of the turret is formed of what may be termed a circular box girder built up of 1¼ in. plates and heavy angles with a depth of 19¼ in. This framework is carried on a wooden lining, which in turn rests in a cast ring that is carried directly on the conical rollers 7 in. in diameter. The rollers run on a circular casting that is carried on wood bolted to the upper plating of the main deck.

Each turret is provided with two small conning-towers located on either side of the gun, and provided with suitable arrangements for handling the turret and the gun, with indices denoting the positions of both. As we have already said, the work of moving the turret, training the gun, and hoisting the ammunition is all done by hydraulic machinery. For this purpose there is a hydraulic plant for each turret, each consisting of two independent pumps built by W. T. Davidson, and to which we will again refer. The specifications required that the combined capacity of the pumps for each turret should be 400 galls. per minute at a pressure of 1,000 lbs. per square inch.

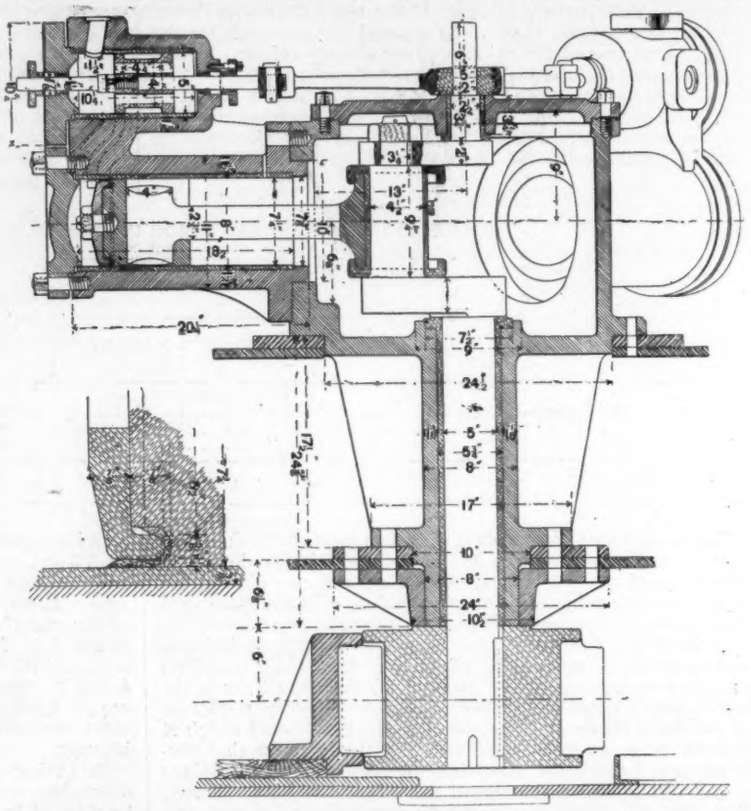
There are two gears for revolving each turret meshing in with a rack bolted to the main deck. The rack is made of cast steel with shrouded teeth and in sections. The pinions are of composition, with a diameter of 18½ in. on their pitch circles and a face of 8½ in. Ample provision is made for oiling the pinions and racks, and a brass drip-pan is placed inside the rack and extending beneath the pinion in all of its positions. The pinions are keyed directly to the lower end of the main shaft of the turning engines. When the contract for the machinery of the *Texas* was taken by the Richmond Locomotive Works, there were no hydraulic engines manufactured in this country that were at all suitable for the work proposed. The requirement was that each engine should have sufficient power to turn the turret at the rate of one revolution per minute, with the gun run out and the ship on an even keel, while the two together are capable of doing the same work when the vessel is heeled 10°. With this problem in view, the hydraulic engines which we illustrate were designed by Mr. C. J. Mellen, Chief Draftsman of the Richmond Locomotive Works.

Before entering into the details of the engines, it will be well to pass in brief review some of the arrangements of the piping, valves, etc., in connection with them. There are stop-valves in both the pressure and exhaust-pipes, so that either engine can be shut off in case of accident. In each sighting station or conning-tower there is a hand-lever for controlling the movement of the turret, which moves the valve of a supplemental hydraulic cylinder through a floating lever, so that the piston follows the motion of the hand-lever, while the piston of this cylinder works through a system of levers and operates the reversing valve of the turret engines. The reversing valve is also so connected to a floating lever that when the turret has revolved to a prescribed limit it (the reversing valve) is automatically closed. The attachment is also so made that in case of such leakage of the valves as to allow the turret to run beyond the limits prescribed, the engines will be reversed. The hand-levers in the turrets are provided with locomotive latches and quadrants. Relief valves are so fitted and adjusted that, when the water is shut off or the engines reversed, the momentum of the turret is gradually overcome by the action of these valves.

Each turret is also provided with an hydraulic locking device, consisting of a cylinder, plunger, and locking bolt with the necessary valve gear. The end of the bolt is tapered to facilitate entering the locking slots, of which there are two, one for each loading position. There is also an interlocking device to prevent the bolts being shot while pressure is upon the turning engines, as well as to prevent the latter being put in motion until the locking bolts are withdrawn.

For a further facilitation of the work there is an index in each turret in plain view of the man stationed at the locking-bolt lever, and an electric bell in each sighting station, which is so arranged as to give warning of the approach to either loading position.

Reverting now to the details of the turret-turning machinery, we would call especial attention to the simple manner in which all of the details have been worked out. As we have said, the engines were designed at the Richmond Locomotive Works for this particular place, and are of the three-cylinder, single-acting type with cylinders set at intervals of 120°. They lie in a horizontal plane and work upon a vertical shaft carrying a pinion at its lower end. The cylinders have a diameter of 7¼ in. and are lined with a composition bushing ⅜ in. thick. The stroke is 12 in. The piston packing is of U section, though it is so held by the follower (see sectional view) that it is converted into a cup packing. The rod is connected to the piston by a T head and oscillating bearing without any take-up. The ends of the rods bear directly against the bushing of crank-pin, and are held in position by return rings on the bushing and washer, as shown in the section. The valves are plain piston-valves of the D type, and are all driven by the same eccentric. The working diameter of the valve-chest is 5 in., and it is lined with a composition bushing $\frac{7}{16}$ in. thick. The valves are of composition with no packing, while the valve-stem is packed with a stuffing-box and gland. The engine, in order to turn the turret in the time specified, must make about 11 revolutions per minute. They are reversed by a special valve shown in half-section and elevation, which converts the exhaust passage of one motion to the inlet passage of the other. The construction will be readily understood from the engraving. The inlet is at the left of the portion shown in section. An examination of the drawing shows that the openings above and below the inlet are closed by a packed valve seated on the metal of the casing. These two valves move in opposite directions, and the opening of one tends to hold the other still more firmly upon its seat by the extension of the spring shown in the side elevation. The combination of levers is such that as one valve rises it lifts its lever, and the spring connecting the two, causes the other to hold its valve down against its seat. The operating lever at the top of the engraving is also so arranged that, as the inlet-valve is raised, the corresponding exhaust-valve in the second casing is lowered. The supply water then enters the passage and, if the lower inlet-valve is opened, passes out through the lower flanged opening to the engines, doing its work and returning to the reversing valve by way of the upper flanged opening. The upper valve of the exhaust casing being open, the exhaust



SECTION OF TURRET-TURNING ENGINE.

water flows down through it to a central cavity and escapes by a similar flanged opening in the right hand casing (not shown), to that by which it entered at the left.

If the engines are to be reversed, the upper left-hand valve is opened and the upper central flanged opening to the engines becomes the supply and the lower the exhaust, thus causing the desired reversal of the motion.

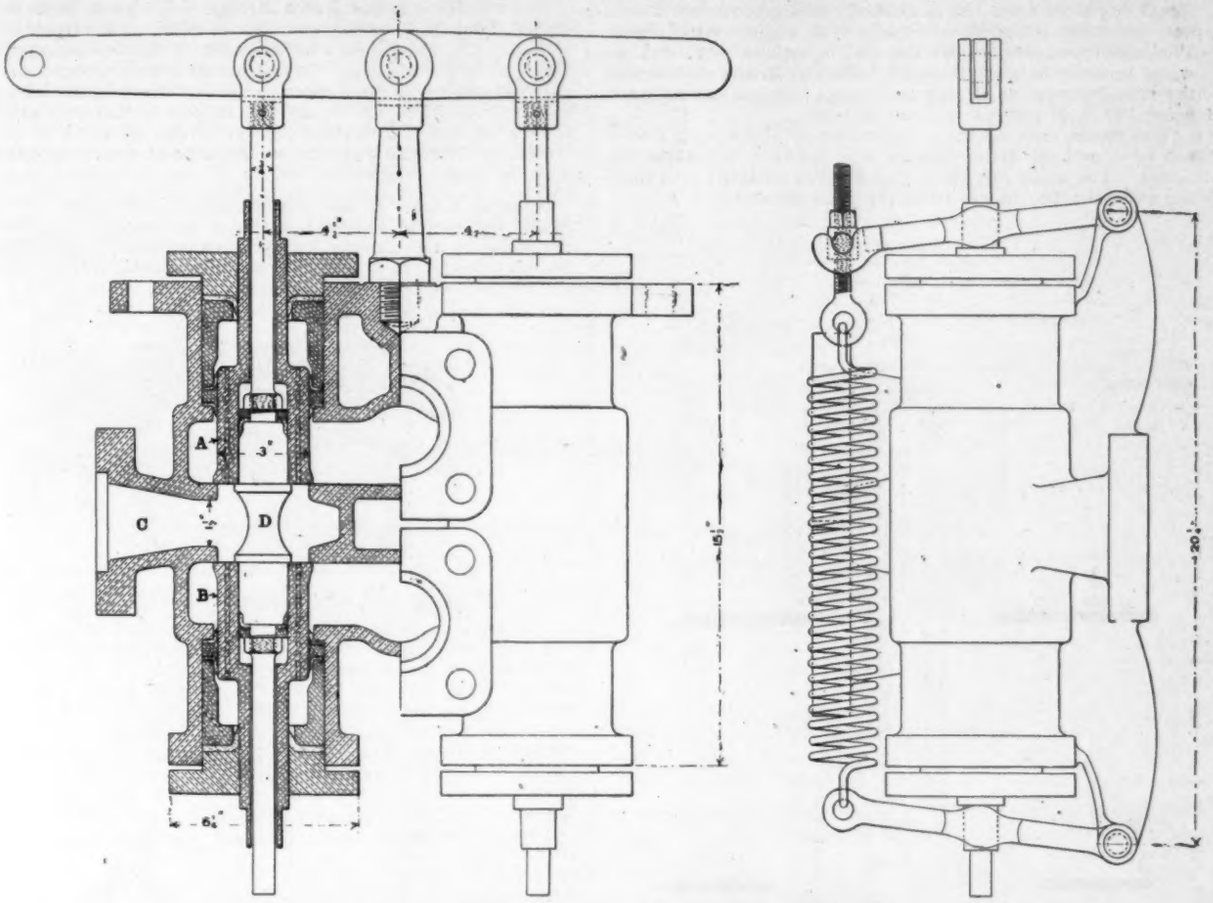
Cup packing is used throughout this valve, and composition metal is used for all of the moving parts.

After the exhaust has passed the reversing valve it is led directly to the center of the turret and into the pivot pipe. This consists of a stand located in the center and receiving the pressure pipe, as indicated on the engraving. The supply water is led up through a central pipe to a point near its upper extremity, whence it goes to the reversing valve, returning from which it enters an annular space and comes down and out at the discharge pipe, as shown. The flanged connections for leading off the supply and receiving the exhaust are on a separate casting that turns about the central supply pipe with the turret. This casting is packed above and below the flanges with cup packings, and is held down in place by the flange held to the top of the supply pipe by the stud and nut, as shown.

The specifications required that there should be an automatic pressure regulator with an adjustable relief valve, and so arranged as to stop and start the pumps when required without allowing the water pressure to fall below 950 lbs.

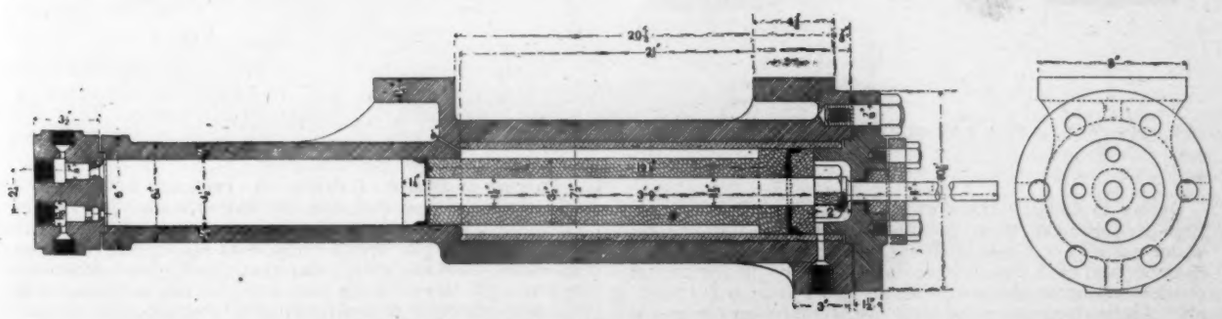
pressure. In order to meet this requirement the pressure regulator, which we illustrate, was designed by Mr. Mellen.

It consists of a cylinder of composition metal in which a piston packed with leather has a free motion, being protected from striking too severe a blow against either head by the rubber packing shown. Water pressure is admitted at the rod end through the 2½ in. opening, and compressed air comes in at the other. As the water pressure rises it forces the piston against the air, and the rod shuts off the pumps through suitable connections. As water is drawn from the supply pipes, the air forces the piston back and starts the pumps. The back end of this regulator is connected with an air compressor that maintains a constant pressure in this cylinder and an expansion tank or air vessel.



REVERSING VALVE FOR TURRET ENGINE UNITED STATES BATTLESHIP "TEXAS."

air must be compressed in two stages, first by an air pump actuated by steam, and second by an air compressor actuated by the water pressure directly from the main pressure pipes. As the air enters from the air pump it forces the ram *down* until it reaches the bottom end of the stroke, where it remains until it is required to have the pressure or the volume of air increased in the air vessel, when, by a simple movement of the lever operating the valves shown in fig. 1, the horizontal valve is opened and the water pressure let in to act on the larger piston, when the air in front of the smaller piston is forced into the air vessel. When the plunger reaches the upper and the motion of the lever is reversed, then the water from below the piston exhausts to the tank, and the operation is repeated when required. As no air is used except that of leakage, an automatic operation of this compressor is not considered necessary, although such an arrangement could easily be attached. Should the air pressure in the air vessel fall below a certain point, there is a tell-tale leak hole in the piston to call attention to the fact.



AIR COMPRESSOR UNITED STATES BATTLESHIP "TEXAS."

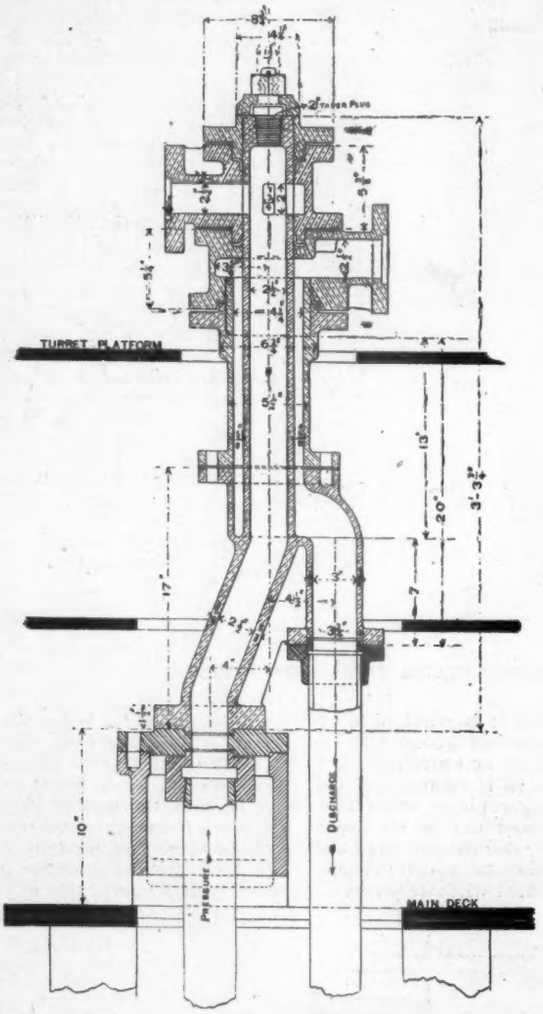
This compressor consists essentially of a cylinder having two diameters and in which a long plunger moves to and fro freely. A sectional view of the head of the small end of the cylinder shows it to be provided with two valves held to their seats by springs.

Due to the high pressure of 1,000 lbs. to the square inch, the

We now come to the hydraulic pumps supplying the pres-

sure for the machinery just described. They were built by M. T. Davidson, of Brooklyn, N. Y., are four in number, each being double-plunger pumps. They are arranged to work in pairs, one pair for each turret. The engraving gives an idea of their general external appearance. Owing to the limited space available and the peculiar service demanded of them, these pumps were especially designed for the place. The steam cylinders are 24 in. in diameter with a stroke of 24 in., and the water cylinders are made with a diameter of 6¾ in. The steam pressure is 100 lbs. to the square inch, and the water pressure to be developed is 1,000 lbs., in accordance with the specifications as already mentioned; the maximum speed being 100 ft. of piston speed per minute.

The steam ends of the cylinders are of the regular Davidson type, and are fitted with metallic packing in the stuffing-boxes. The main valve is a piston valve operated by a rocking valve driven directly from the main piston-rod.



PIVOT PIPE FOR THE TURRET OF THE "TEXAS."

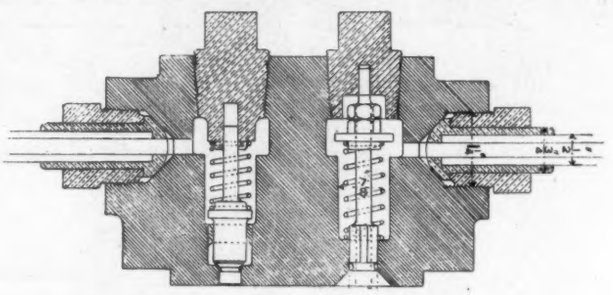
Owing to the difficulty that has been experienced in heavy-pressure pumps of strengthening the flat valve surfaces, each water valve in this pump has a separate cylindrical pocket or chamber and each two contiguous valves have their own independent outlet to the manifold, no valve plate being used at all. The valves and valve seats are of phosphor bronze, the valves having a lift of ¼ in. They are very easy of access, and any valve may be removed by unscrewing the cap screwed in above it. Each pump weighs 4,500 lbs., and has a length of about 9 ft. over all; the width is 28 in. Each pair of pumps, with all fittings, tanks and attachments, occupy a space of 9 ft. 6 in. × 7 ft. 6 in., with ample room left to remove cylinder heads or doing any other necessary work of examination or repairs.

NOTES AND NEWS.

The Large Krupp gun recently exhibited at the World's Fair, Chicago, was loaded recently into the steamship *Turrett* at Sparrow's Point, Md., without incident or hitch of any kind.

A New Mississippi River Bridge.—Contracts have been signed for a new bridge over the Mississippi River at New Orleans, and the Phœnix Bridge Company, of Phœnixville, Pa., will be the builders. The structure is to be about 2 miles long, double track throughout. The approach spans vary in length from 25 to 150 ft., as the heights of the supporting towers increase. The river portion of the bridge is to be a cantilever structure with two anchor arms of 608 ft. each, and a central span of 1,070 ft.

Spanish Cars.—In the construction of passenger cars in Spain, the system followed is almost analogous to methods prevailing in the principal European car-works. The skeleton frame of the bodies is ordinarily made of selected oak and elm,



HEAD OF AIR COMPRESSOR, SHOWING VALVES.

while mahogany or teak provides for the outer roof, and receives nothing but a coat of varnish. As to the interior, the sides are fixed up with painted red-pine linings, or with fine woods, or tapestry-covered, depending on the rank of the car. It is usual to build with all iron frames, steel axles, steel-tired wheels, the wheel centers being of stamped or forged iron. These central parts are never made of cast iron nowadays. The measurements, which are more ordinarily followed in the builds of cars and trucks, are the same as the common European ones, which range from 6 to 9 m. long, with a box width of 2¼ to 3¼ m. The long passenger cars common to the United States, bogie-mounted, were introduced several years ago into Spain, and are slowly but steadily coming into favor. The chief car-builders of the peninsula, Sociedad Material para Ferrocarriles, of Barcelona, are constructing a number of them.

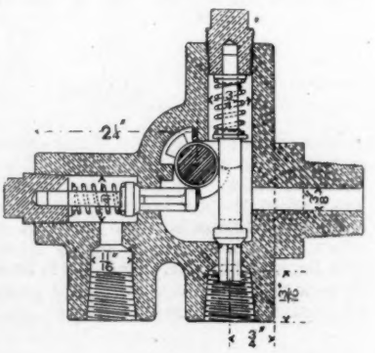


Fig. 1.

Narrow-gauge freight cars are also made on a large scale in Iberia, to a gauge of 1 m. (5 ft. 4 in.). The construction is similar to those run on the standard 5-ft. gauge. They weigh about 6,000 lbs., and are registered for carrying 14,500 lbs.—*The Indian Engineer.*

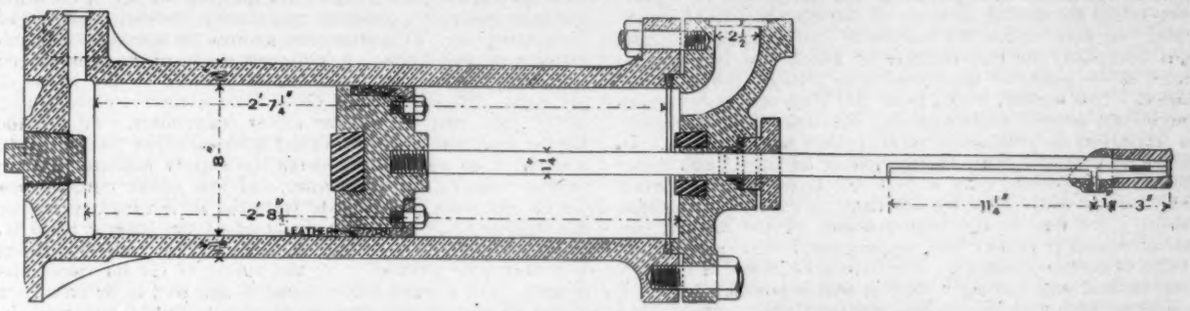
Parrots as Station Callers.—An exchange is authority for the statement that almost every station-master on a German railway has a parrot or starling so trained that whenever a train draws up to the platform it commences calling out the name of the station most distinctly; and not only this, but continues doing so while the train remains there. While we have not seen this remarkable example of saving in lung power in our travels over Germany, the scheme is certainly a simple one. How would it do to have the parrot as an auxiliary to the ordinary train-hand who naturally inquired from Mr. Depew what kind of a tenor he would expect to get for $40 a month, when the rule was issued on the New York Central & Hudson River Railroad that all stations should be announced distinctly? The only time we have ever heard the stations announced distinctly was when we were in company with some of the upper

officials of a railroad ; then the tenor voice of the brakeman has no difficulty in obtaining a distinct enunciation, but upon the disappearance of the official the voice at once relapses into a long howl, which is utterly unintelligible. Perhaps if each brakeman were equipped with a parrot the improvement in service would be very great.

Raising a 60-ton Engine.—The *Portland Transcript* gives the following account of the raising of a Canadian Pacific mogul engine that ran off an embankment into Harvey Lake on the night of January 13. The work was carried on under great difficulties, with the thermometer often being at 30° below zero, and with a snow blowing over the lake at times more than 50 miles an hour, causing a suspension of the work for days at a time. In preparing to raise the locomotive, weighing 60 tons, 16 holes, 3¼ in. diameter and 20 in. deep, were drilled in the solid rock, and as many steel posts were planted and set in lead. These were for fastening guy lines and purchases, and the men who drilled and set the posts were kept from freezing by the aid of fires kindled upon the snow. A number of ingenious fastenings for purchase blocks were made very near the track by sinking heavy oak timbers in trenches at the ends of the ties that were tamped with gravel and wet, which after 24 hours were frozen so solid that they were quite as strong as the iron fastenings upon the bluff. Very heavy sheer poles 30 ft. in length were built and erected to overhang the embankment, and were provided with two sets of very heavy ship blocks and falls for lifting, and two of equal strength were placed in position for pulling from the bluff. As no diver was employed, everything was done from the surface, and every precaution was taken to prevent delay to trains. By the aid of a swinging mirror attached to a long pole, with light thrown upon it in the night by a dark lantern, successful fastenings were made to the engine 15 ft. under water with heavy grappling hooks. The driving-wheels were badly entangled in bowlders, rendering it next to impossible to move the monster. With three locomotives working upon independent purchases, and aided by the buoyancy of the water, it was finally drawn to the surface. At one time, while attempting to raise the engine and tender, it was found that the locomotives were exerting a force of 240 tons.

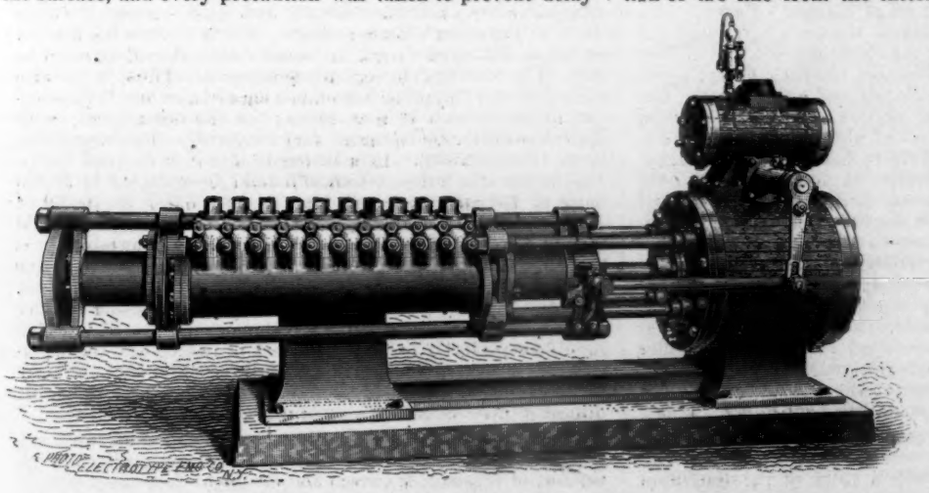
Aluminium Horse-Shoes.—Concerning his experience with horse-shoes of aluminium, M. Japy reports that as that metal is four times lighter than iron, a complete outfit of shoes of it will weigh no more than a single iron horse-shoe. Horses accustomed to iron shoes when shod with shoes of aluminium imagine themselves barefooted, and are as careful in planting their steps as if they were unshod. The shoes open out as the hoof expands, and consequently never cramp it. An aluminium horse-shoe will last from 40 to 60 days, according to the composition of the alloy and the kind of work done by the horse. M. Japy concludes that aluminium can be utilized in shoes for race and carriage horses, and that it may be of service in the treatment of diseases of the hoof. It should, however, be used only by persons experienced in working the metal.—*Popular Science Monthly.*

Wind-Power and Electricity.—Professor James Blyth, who has been experimenting in the utilization of wind-power for the generation of currents, was the first to make trial of the windmill at Marykirk, in Scotland. He first adopted the English type of windmill having four arms and canvas sails ; but the sails were too easily torn during a head-wind—the very time they were most required. Next he used the American type, having a number of arms and blades of cast iron. He has now devised a new system. To four strong arms, each about 26 ft. long, he attached semi-cylindrical boxes, the opening of each box being 10 ft. by 6 ft. The vertical shaft is a long rod of iron 5 in. in diameter. At the lower end it carries a massive pit wheel, which actuates a train of gearing, and drives a fly-wheel 6 ft. in diameter. With a fair wind speed it gives 4 electrical H.P.; and it works very satisfactorily in a strong gale.—*Electricity.*



HYDRAULIC PRESSURE REGULATOR UNITED STATES BATTLESHIP "TEXAS."

"The Indian Engineering" tells a story of the construction of the line from the interior of Manchuria to the coast, and along which it was recently proposed to make a junction with Moukden, the chief point. The engineers consulted the Tartar general, and the general, before giving his sanction, consulted the geomancers, who declared that if the line were laid along the proposed track, the vertebræ of the dragon that encircles the city would be broken by the nails of the sleepers. Such a contingency was too awful to contemplate, and the general promptly informed the engineers that the thing was impossible. The latter, in despair, lodged a protest with Li Hung Chang, who, while commending the caution of his subordinates, expressed it as his opinion that the hidden dragon would suffer no harm, rather otherwise, by the innovation. However, he would refer the matter to the Emperor. This struck terror into the heart of the general, and he again consulted the geomancers. Eventually a line was traced some hundreds of yards away from the site at first proposed.



HYDRAULIC PUMP UNITED STATES BATTLESHIP "TEXAS."

A Universal Telescope Stand.—The construction of a good and simple universal mounting for small telescopes has been the aim of many instrument makers, and it is pleasing to note an advance in this direction made by a firm in Vienna. In their new so-called "universal station" they have overcome many of the main difficulties. The chief point about this special kind of mounting is that the observer can either use the telescope as a theodolite—that is, with circles reading altitude and azimuth—or by a slight adjustment he may have the equatorial mounting where the circles read right ascension and

declination. This end is gained by hinging what would be the polar axis on to a pivot at the side of the stand, thus allowing the axis to be moved from the horizontal to the vertical or any intermediate position. A strong metallic arc fixed on the top of the stand supplies a means of clamping this axis and giving it a slight adjustment. With the axis vertical, we have then practically a theodolite mounting With the axis out of the vertical, a parallactic mounting. It is needless to say that this mounting is only for small telescopes, and indeed its application to large ones is not needed.—*Nature.*

Incandescent Gas Lighting.—Cannel coal is generally used for enriching ordinary coal gas and imparting to it the standard illuminating power. Owing, however, to the decreased yield of that mineral, the price of it has gone up excessively, so that gas engineers are casting about for a substitute. In the meantime, it has been suggested that gas of a comparatively low candle power might be supplied to the public, and its illumination raised by special methods of burning it. In this connection we may notice the burner of the Incandescent Gas Light Company, the manufacture of which was recently inspected at the works of the company in Palmer Street, Westminster. This burner, which is on the Welsbach system, was brought out several years ago, but has since been so altered and improved as practically to constitute a new article. It consists of a mantle which is formed of an open mesh material, and is suspended over a Bunsen gas burner. On being brought to a white heat by the flame it gives out a bright glowing light due to the incandescence of the mantle, the basis of which is cotton lace, impregnated with a chemical solution of certain minerals. The lace is dried and the cotton fabric burned out, leaving a mantle which consists solely of the mineral with which the fabric was originally impregnated. After further treatment with collodion the mantle is ready for use. The points of recent improvements in this mantle relate mainly to the chemicals used in its preparation. The results are stated to be that, whereas formerly when burning 3.75 cub. ft. of gas an hour an illuminating power of from 26 to 28 candles only was obtained, with the mantle in its present form, burning the same quantity of gas per hour, a light of 60 candles is obtained. Subject to the contingencies of practical use the life of a mantle is put at 800 hours. The advantages of the incandescent system are purity of the atmosphere, owing to perfect combustion, a diminution of heat, and a great economy of gas, which, according to Professor Renk, amounts to as much as 50 per cent. as against the fishtail or the Argand burner. The company are now introducing a form of incandescent lamp for street use.—*London Times.*

The Baltimore & Ohio's Cut-off at Harper's Ferry.—The new Baltimore & Ohio route through Harper's Ferry was put in operation recently, and after that hour the old route, from Sandy Hook and through the village of Harper's Ferry, about 2 miles altogether, will be abandoned and subsequently dismantled, including the railroad portion of the old bridge. The improvements, made at a cost of about $250,000, include 2 miles of double track, a tunnel 875 ft. in length, under Maryland Heights, and a new iron bridge of nine spans and over 1,000 ft. in length, over the Potomac River. The bridge is of considerable elevation, being 9 ft. higher than the old bridge, and built to stand any freshet likely to occur, and also to allow free passage for canal-boats underneath. The old line from Sandy Hook, as will be remembered by travelers familiar with the route, was close alongside the water's edge, while the new line takes considerably higher ground, and some distance from the river bank. The improvement was made entirely under direction of the Baltimore & Ohio Engineering Department. The junction of the Valley Road at the Ferry has also been changed to meet the improvement.—*Baltimore Paper.*

Chinese Obstacles to Railroad Building.—The late Mr. Charles Hill, who was actively interested in the first unfortunate railroad built in China, tells a story of the opposition met at the hands of the natives to the laying of rails, and which finally resulted in the tearing up and destruction of the road and property. In one instance it became necessary to pass the house of a widow, and to fill up a little pool of stagnant water near by. She immediately asserted that the spirit of her husband would not rest easy in his grave with the railroad running between her house and it, and that the spirits protecting them would be smothered by the filling up of the pool. The natives gathered in some force to prevent the laying of the rails, and Mr. Hill found himself deserted by his workmen and left alone to face the mob. Starting on a retreat, he was followed by the hooting assemblage for several miles, and finally came to bay on a narrow foot-bridge crossing a river. Armed with a strong cudgel he defended himself, and as fast as his assailants came up knocked them into the river, rendering them unconscious, but never learned what harm he had done. They were armed with long bamboo poles with which they prodded him on the legs and body, inflicting wounds the scars of which he carried until his death.

Lighthouse without an Attendant.—A new lighthouse has been recently completed in the estuary of the Gironde in France. It stands on an isolated rock, and its chief peculiarity is that it is unoccupied, although its lamp is burning perpetually. In order to do away with the lonesome life which is led by such keepers as those having charge of the Eddystone Light in England, the French engineers have devised a method by which the usefulness of the lamps could be maintained without constant personal attention. The lamp which is used will burn continuously for one month without being trimmed or replenished. The burning fluid used is an ordinary mineral oil. The tube in the interior of the lamp is furnished with a wick having a thickness three times as great as that usually employed in lamps. Around the burning surface of the wick is a cake made of a patented preparation consisting largely of carbonized tar. This protection assures the operation and uniformity of the flame. A chimney made of mica is placed around the flame, and this gives an increase in the power of the light. The supply of oil is from a reservoir containing .88 oz., the lamp consuming 1.8 oz. each hour. To provide for the reservoir being furnished with sufficient fuel, a gauge is fixed at its side that governs the supply flowing in from another reservoir at a distance, and this gauge permits just 1.8 oz. per hour to percolate from the little supply-pipe into the supply reservoir. The diameter of the lantern is 56 in. The light can be seen 12 miles at sea. The wick is cleansed and drawn up gradually by the action of the tar cake at its mouth. The French Government is also said to be arranging to put up other lighthouses in which a perpetual electric light can be controlled by wires running through a submarine cable to the land.

Method of Baling Cotton.—The consular reports of the State Department for December call attention to the fact that there is a great deal of trouble experienced by foreign importers with the baling of American cotton. The jute covering is so torn that the cotton is exposed to mud, fire, water, and theft. Of the original six or eight bands, two, three, four, and sometimes more are loose and broken by the time the cotton reaches its destination, allowing it to take up dust, dirt, mud, and water when exposed. In contrast with this the packing of the Egyptian and Indian cotton is very much superior. Both Egyptian and Indian have close, compact, tough coverings, are rather long and smooth, leave little or none of the cotton exposed, are easily and plainly marked, and are wrapped close and bound strong and tight. Along the sides the firm's or seller's name appears. On both ends the kind of cotton is indicated to aid in identification should one end be torn off in handling, as sometimes happens. Thus, in the case of Indian and Egyptian cotton, mixing of bales and bales without marks seldom if ever occur; on the other hand, with American cotton both happen very frequently—too frequently, hence the complaint. In addition to this it is claimed by the Lloyds that the vessel which will hold from 16,000 to 18,000 bales of Indian cotton can take in only 6,000 to 10,000 of American, when according to the ratio of weights they should take in 14,000. The fear which was formerly entertained that the enormous pressure used in India would injure the fine fibers of the American cotton has proved to be groundless, from the fact that the Egyptian cotton with as fine or finer and longer fiber has stood a greater pressure. The cotton should be perfectly dry, in order that no caking and fermentation may occur in the inside. This is a matter that certainly deserves the attention of American shippers, and is of the utmost interest to American manufacturers.

Lewis and Hunter's Coaling System.—In the ordinary method of loading coal from colliery wagons into ships a large amount of breakage is caused and clouds of dust are produced by reason of the coal having to fall from a considerable height, sometimes as much as 24 ft. With the view of obviating these evils, which are a source of pecuniary loss, Sir William T. Lewis, General Manager, and Mr. Charles L. Hunter, Engineer, of the Bute Docks, Cardiff, have invented a system of shipping coal by which the greatest fall is only 5 ft., and the mineral is quietly deposited in the hold of the ship. It consists in tipping the coal from the colliery wagon into a carrying-box having a coned valve-bottom which can be released at will. These boxes hold a 10-ton wagon-load of coal each, and as they are only about 5 ft. deep, it follows that only a portion of each load has even that short distance to fall. As soon as the carrying-box is filled it is raised by a traveling crane worked by hydraulic power, and lowered into the hold of the ship. Directly it reaches the bottom the coned valve is released and the coal glides quietly out with hardly any break-

age. The box is then raised and transferred to the loading-stage for another charge, which is quickly tipped into it and as quickly transferred to the ship. The system has been adopted by the Bute Docks Company at their Roath Dock, where a series of the traveling cranes are at work on lines of rail extending over 2,000 ft. of quay space. The cranes are self-propelling, and are not only movable and provided with a swing motion of some 40 ft. radius, but they also have a derricking motion, so that they can plumb both hatchways and coaling pits at will. This derricking motion also enables the crane-man to steer the loads clear of the funnels and rigging of the vessels. The *maximum* speed of loading is 300 tons per hour per crane, and it is stated that 293 tons of coal have been shipped in an hour by one crane. With this system as many as four cranes, each lifting 10 tons of coal, have been employed simultaneously in loading the same vessel, as the cranes can be brought into such positions as to plumb the steamer's hatchways. A model of the system was recently exhibited at the Coal Exchange, London, where it attracted merited attention. —*London Times.*

The Thinnest Metal Sheet.—An interesting metallurgical achievement has been lately recorded at the Hallam Tin Works, near Swansea, Wales, a metal sheet of the finest appearance and most marvelous thinness ever yet produced. The details show that the iron from which the sheet was rolled was made on the premises, worked in a finery with charcoal and the usual blast, afterward taken to the hammer to be formed into a regular flat bottom, from thence conveyed to the balling furnace, and, when sufficiently heated, taken up to the rolls, lengthened, and cut by shears into proper lengths, piled up, and transferred to the balling furnace again; when heated it was passed through the rolls, back again into the balling furnace, and, when duly brought to the proper pitch, taken to the rolls and made into a thorough good bar. On being taken now to the tin mills and rolled until it became thinner than 23 grains, and afterward passed through the cold rolls, to give it the necessary polish, it stands on record as the thinnest sheet of iron ever rolled—that is, the data show a sheet of 10 × 5½ in., or 55 in. surface, and weight but 20 grains, which, being brought to the standard of 8 × 5½ in, or 44 surface inches, is but 16 grains, or 30 per cent. less than any previous, and requiring at least 1,800 to make 1 in. in thickness.—*The Tradesman.*

Model of Locomotive.—We have received a photograph of a piece of work which was lately completed Mr. S. E. Mastin, of Odenweldertown, Easton, Pa., and which is worthy of note. The work is in the shape of a miniature locomotive of about one-sixteenth size. It is made to represent an express locomotive which was built for the New York Central & Hudson River Railroad in 1889 by the Schenectady Locomotive Works, and is made entirely of wood and cut out in full with a penknife. Mr. Mastin is not an engineer, nor has he ever worked on a locomotive; but the work on which he spent five months and two days should win for him a situation in some locomotive works, as he would in all probability make a suitable man for any works of the kind, as his sole desire is for that kind of occupation. The dimensions of the miniature locomotive are as follows:

Length over all	3 ft.	1¼ in.
Height to top of stack		14 "
" " " " cab		13½ "
Width of cab		8½ "
Diameter of boiler		4¼ "
" " driving-wheels		5¼ "
" " truck "		2¾ "
" " cylinders		2 "
Length of "		3¼ "
" " boiler	2 ft.	

Time of building, five months and two days.

Mr. Mastin will send photos to any locomotive shop wishing them by writing him.

The photograph gives an excellent representation of a locomotive, and it is only by close examination that it appears that it is not taken from a full-sized machine.

Compound Locomotive of the Richmond Locomotive Works.—A compound locomotive engine of the ten-wheeled type, built by the Richmond Locomotive Works, has recently been tested on the Big Four Road. The engine is a two cylinder compound with cylinders 19 in. and 30 in. × 24 in. The weight of the engine alone is 68 tons, and the drivers are 56 in. in diameter. The steam pressure is 180 lbs. to the square inch; the driving-wheel-base is 11 ft. 10 in.; the truck-wheel-base, 79 in.; the total wheel-base being 23 ft. ½ in. The length over all with tender is 58 ft. 2 in.; the weight on the drivers is 107,100 lbs.; the weight of tender, running with coal and water, is 79,000 lbs. The boiler is of the Belpaire type, and is 58 in. in diameter, with a shell $\frac{9}{16}$ in. thick. The fire-box is 107 in. long by 41½ in. wide; the grate area is 31 sq. ft.; the fire-box has a heating surface of 172 sq. ft., and the heating surface in the tubes is 1,750 sq. ft. There are 241.2 in. tubes. The driving-wheel journals are 8 in. in diameter by 9½ in. long; the truck wheels are 28 in. in diameter, with journals 5½ in. in diameter by 10 in. long; the valve travel is 5½ in. The engine was designed by Mr. C. J. Mellen, Chief Draftsman of the establishment, who also designed the engines and machinery for the United States battleship *Texas*. The reported saving in fuel runs from 30 to 35 per cent. A compound of the same type has been in continuous service for 14 months on the Philadelphia division of the Chesapeake & Ohio Railroad, and has made a record of saving 21 per cent. in fuel over 22 simple engines of the same class. The cost of repairs has been no more than other engines, and it has been run in chain gang methods with the rest.

Railroads in Japan.—The railroads of Japan are solidly constructed and carefully run, says the Philadelphia *Telegraph*. The gauge is 3 ft. 6 in., and the cars are generally 18 ft. long. There are first, second and third classes, and the fares are for several classes 1, 2 and 3 sen (cents) a mile. The Japanese are great travelers, and more than nine-tenths of the travel is of second and third class. The rate of speed is uniformly about 20 miles an hour. The trains are run on what is known as the "staff" system, and a train is not allowed to leave the station where it meets another until the conductor has received from the conductor of the other train a symbol called a "staff," which is his evidence that he is entitled to leave. In the first-class carriage, which is either one room, like our drawing-room cars, or in three compartments, like the English, one finds cushion seats, wash hand bowls and water-closets, and generally a teapot and cups, the former occasionally replenished with hot water. If this is lacking, the passenger can buy on the platform at any station a teapot full of tea and a cup for 2½ cents. The teapot is pretty enough to bring a quarter in this country, and the cup would be cheap at 10 cents. You buy the whole "outfit" and could carry it away if you pleased. As a rule, the pot and cup are left in the car and about 60 per cent. of them are recovered by the venders. The railroads in Japan are partly owned by the government and partly by private stockholders, but the rates and rules of the government roads govern the others also. At all the stations are overhead bridges, and crossing the track at grade is prohibited, as in England. The stations are roomy and neat, the platforms ample, and at both ends of the platform the name of the station is conspicuously posted. The passenger shows his ticket on going through the gate to his train, and surrenders it at the gate on leaving. No conductor enters the cars. We also miss the familiar visits of the enterprising young man who sells newspapers and popular books, and who loads our seats at home with lozenges, photograph albums, comic periodicals, vegetable ivory, matches, chewing-gum, and other merchandise.

Electricity as a Motive Power.—The report on street railroads of the Massachusetts Railroad Commissioners was presented recently. It shows an increase of 214 miles of electric roads and of over $25,000,000 in capital so invested. Of the comparative economy of electric motive power it says:

"We must conclude, taking everything into the account, that there has been thus far no demonstration of the superior net-earning capacity of the electric as compared with the horse system, but rather the reverse. It is not, however, intended to raise the inference that the electric system is or is likely to prove, under conservative and proper management, a serious financial failure. The conditions attending its further and fuller development will probably be found to differ in no essential respect from those attaching to the old horse-railway system, or to the steam-railroad system. A well-located and well-managed electric railway, it may be fairly said, stands a similar chance of financial success with a well-located and well-managed steam railroad or horse railway. Upon the present showing and outlook, it certainly stands no better chance. If badly located or badly managed, there clearly has not been manifested as yet any miraculous power in its peculiar system of locomotion to save it from the familiar fate of the steam railroad or horse railway when struggling under the same difficulties.

"It can and should be said, however, without hesitation or qualification, that the electric system has not shown or indicated any such margin of profit as to justify the expectation of more than moderate and ordinary returns on money legitimately invested in it. The idea, which seems to have obtained some currency, that the electric railway system is a bonanza of rare and inexhaustible wealth, is clearly a delusion, and has doubtless proved to some a snare. The absolute cost and ex-

pensiveness of the system, under the most conservative, able, and honest management, are sufficient to task its earning capacity to the full limit. There is no margin for fictitious or inflated capitalization. It presents no safe or inviting field for speculative enterprise or manipulation, unless it be to the unscrupulous operators of an inside ring who are willing to practise on the credulity of a misinformed public. Wherever there is reason to believe that water has been, or is about to be, injected into the stock or bonds of an electric-railway company, the only safe course is to let its securities severely alone."

Rapid Method for the Determination of Manganese in Manganese Bronze.—The following method was originated by Mr. Jesse Jones, Chief Chemist, and is in use in the laboratory of William Cramp & Sons, Philadelphia, Pa., for the determination of manganese in manganese bronze. It is an adaptation of a well-known method in common use for the determination of manganese in iron and steel. A determination can be made in less than one hour, and as the amount of manganese in the ordinary run of work seldom exceeds 0.10 per cent., the method gives fairly satisfactory results.

The Method.—Dissolve 5 to 10 grams of drillings in nitric acid of 1.20 sp. gr., using a large beaker to avoid frothing over. An excess of acid must be avoided, as it interferes with the precipitation of the copper by hydrogen sulphide. When solution is complete, transfer to a 500 cc. cylinder without filtering out the precipitated stannic oxide. Make up to 300 cc. and pass a rapid current of hydrogen sulphide from a Kipp's apparatus until the supernatant liquid is colorless. Decant off through a dry filter, 180 cc. corresponding to 3 or 6 grams of sample, and boil down rapidly to about 10 cc. Transfer to a small beaker and add 25 cc. of strong nitric acid. Boil down one-half, make up with strong nitric acid, boil, and add one spoonful of potassium chlorate. Boil 10 minutes and add another spoonful of potassium chlorate. Boil till free from chlorine, cool in water, and filter on asbestos, using filter pump. Wash with strong nitric acid through which a stream of air has been passed. When free from iron wash with cold water until no acid remains. Place the felt and precipitate in the same beaker and dissolve in ferrous sulphate, using 5 cc. at a time. Titrate back with permanganate until a pink color remains. Deduct the number of cc. used in titrating back from the number of equivalents of ferrous sulphate used and the remainder shows the manganese in the amount of sample taken.

Permanganate Solution. Dissolve 1.149 grams potassium permanganate in 1,000 cc. water; 1 cc. equals 1 mgr. manganese. Check by dissolving 0.1425 grams ferrous-ammonium sulphate in a little water and acidulating with hydrochloric acid. This should precipitate 10 mgr. of manganese. If not, apply the factor of correction.

Ferrous Sulphate Solution.—A solution of ferrous sulphate in 2 per cent. sulphuric acid, so dilute that 5 cc. corresponds to 10 cc. permanganate solution. This is best made by trial and dilution.

Crank Axles.—In a letter on this subject by Mr. Clement E. Stretton, the indefatigable investigator of locomotive history, published in the *Railway Herald* recently, he says:

"There is no question that the first inside cylinder engine, having, of course, the double-cranked axle, was the *Planet*, designed by Stephenson toward the close of the year 1829, which commenced work upon the Liverpool & Manchester Railway, October 4, 1830. It was a striking improvement upon all previous passenger engines. The cylinders were placed 'inside,' under the smoke-box, the driving-wheels were at the trailing end, and a double-cranked axle was employed. The frame was of oak, plated on both sides with iron, and the driving-axle was above the frame.

"The cylinders were 11 in. diameter, 16 in. stroke, and driving-wheels 5 ft. diameter. During the time this engine was under construction, Stephenson built another engine for the Stockton & Darlington Line, the only difference being that it had four large wheels, and these were coupled; it was also named *Planet*. The fact that two engines were built in 1830, and both named *Planet*, has in years past caused some trouble to writers on the locomotive; however, all difficulty is now removed by the bringing to light of the official drawings and records of both engines.

"The fact that Stephenson had adopted the cranked axle and inside cylinders for both 'single' and 'coupled' engines was common knowledge early in the year 1830. When a number of engineers went to Newcastle to witness the method of forging the crank axle, several of those present, being in favor of outside cylinders, took but little interest in the subject; but two at once saw the value of the inside cylinder system, the result being that Mr. Hackworth then designed the *Globe*, well known on the Stockton & Darlington Line, and a very close copy of Stephenson's second *Planet*. Shortly afterward Mr. Bury designed an engine named *Liverpool*, which was completed and sent to America in 1831, and of which pattern large numbers were afterward built.

"The advocates of Mr. Bury at one time claimed that he built an inside-cylinder engine in 1829, but they have been obliged to admit that this was not the case; it was said to have been built for the Liverpool & Manchester Railway. However, an investigation of facts, working drawings, and official papers shows that Mr. Bury built no engine whatever for that railway until the *Liver*, which he placed on the rails in February, 1832, and the company did not order any more than this one on the Bury design. Of course, it is well known that the *Planet*, by Stephenson, was intended to be the engine to open the Liverpool & Manchester Railway, September 15, 1830, and it was sent off from Newcastle to Hull, and by canal from Hull to Manchester, delays took place, and the engine was not delivered by the boat companies until early in October, or fully a fortnight after the opening. Under these circumstances *Northumbrian* opened the line, and eight engines, instead of nine, were in the procession.

"As to frames, the 'bar-framing' was first made at Newcastle, and has been generally adopted in America; but it is an English invention, and was sent out from this country in 1828."

New Signal Device.—There was an exhibition recently before the Royal United Service Institution of a new device for signaling at sea by night or day. It was the invention of Mr. C. V. Boughton. The object aimed at is to signal by the Morse alphabet, displaying simultaneously all the symbols which go to make up a letter or signal, instead of flashing them from the mast-head in succession. It is claimed that 100 letters were sent per minute by the new apparatus. The theory of the telephotos, as it is called, is a production of the symbols by electric lighting in lamps mounted on a long shaft, 10 lighted lamps in a line of 5 ft. length representing a dash, and one light a dot. There is an unlighted interval between each dot or dash of at least 5 ft. in length. The number of lamps required is 53, and these are mounted on a shaft 27 ft. long. The switch-board is only 11 in. × 14 in., and may control lamps for two shafts. It is fitted in a case mounted on a pedestal. At one end of the pedestal is fitted a keyboard, corresponding to that on a typewriting machine, and the keys have raised on their under sides the Morse characters, for the respective letters, in brass with platinum points. The crossbars, 106 in number, are flexible and imbedded in hard rubber. The pressing down of the key makes contact with such crossbars as are immediately opposite to the platinum-pointed brass projections on the key corresponding to the Morse symbols which represent the particular letter. Wires are led from each crossbar to a lamp on the shaft, and thus the signal corresponds with the symbols. A groove under the keys contains a number of fine steel balls similar to those used in the bearings of cycles, with $\frac{1}{16}$ in. of lost motion the thickness of the key. The pressing down of the key causes these balls to lock all the other keys. The lamp is of special construction. It is flatter in the face than the usual incandescent globe, resembling an ordinary door knob, and the filament of 10 coils is placed crosswise in order to secure the greatest light surface. Each lamp is fitted into a special bell-mouthed casing with a parabolic metal reflector, and in front there is a lens screwed on. This latter, it is said, has the effect of screening the expiring incandescence of the filament of the lamp. Of course it will be understood that the lamps may be used for any or all successive letters, for the lamps used are determined by the spacing necessary for the symbols in the letter, and here it may be stated that where practicable the symbols are as far divided as possible. Thus "m," equal to two dashes, would require 10 lights at either end of the 27-ft. shaft to be lighted, while "i," equal to two dots, would require the extreme end lights on the shaft to be illuminated. An important consideration is that by auxiliary mechanism a permanent record in writing of the signal given is kept. Above the keys for making the electrical contact with the crossbars is a cylinder with an adaptation of the ordinary typewriting machine, and 36 double magnets for throwing the Roman type of the symbol displayed on the proper ribbon. This recording apparatus may be kept under seal. There are a great variety of means of applying the invention. Several navy officers, while recognizing the ingenuity displayed, seemed inclined to regard it as much too intricate, and therefore liable to get out of gear. Admiral Colomb expressed a desire for a more intimate acquaintance with the mechanism, which he seemed to regard as unique in conception.—*Philadelphia Record.*

SIGNAL APPARATUS IN USE ON THE GRAND CENTRAL RAILWAY OF BELGIUM.*

By Leopold Kirsch.

In 1889 the management of the Grand Central Railway of Belgium exhibited at Paris the apparatus which is used on their line for the manipulation of points and signals which are some distance from the signal cabins, and since that time the apparatus in use has been greatly increased. Experience has shown that it is thoroughly adapted for the work which it has to perform, and leaves absolutely nothing to be desired in the transmission of motion to distant points. The mechanisms are simple, light, easy to locate, compact, and comparatively inexpensive; they are, furthermore, absolutely safe, and in adopting them certain elementary cautions have been taken.

General Considerations.—Among the causes which can exert a disturbing influence on the action of the apparatus there are three which should receive the particular attention of the engineer: The influence of the temperature, that of elasticity, and the breaking of wires. The first question brings up the inquiry whether or not it is necessary to provide the apparatus with compensators.

This question is a matter of discussion, and we would refer to an interesting notice published by Mr. Colin in the *Revue Générale de Chemins de fer* for August, 1893, in which he discusses and calculates the strains which should be put upon wires for a double transmission in order to operate a point, and assure its perfect action in spite of the variations of temperature, and without having recourse to the use of compensators or regulators.

According to his theory, at the time when the apparatus is set up, the tension of the wires should be ascertained, account being taken of the distance, the size of the wire, the distance between supports, the prevailing temperature, and the variations of the temperature admissible for the locality where the work is done. We would add that it is also necessary to take into account the contour of the line of transmission. The contour may have a very great influence upon the resistance, and consequently upon the initial tension which must be given to the wire. The variation in tension is considerable, since even adopting with Mr. Colin 1,050 ft., 1,312 ft., and 1,640 ft. as the limiting length which should not be exceeded with wires of .14 in., .173 in., and .2 in. in diameter. The tension with the lowest temperature in our climate may vary respectively from 364 lbs. to 697 lbs. and from 465 lbs. to 1,096 lbs. and from 611 lbs. to 1,320 lbs., according to the distance between supports, and may show a variation of 344 lbs., 434 lbs., and 571 lbs., according as the temperature is lower or higher.

The application of this theory does not seem to us to be one that can be recommended. It makes the original application and maintenance of the required tensions a delicate and complicated operation. With temperature charts taken from observations in our climate, the tension of a wire may vary from a little over 50 per cent. to nearly 100 per cent. Now, in a case of absolutely straight transmissions these changes of temperatures have a relatively slight influence on the operation, which becomes very different when the transmission runs around curves or polygons, or as sudden changes in direction. In the latter case, which are the most frequent, the difficulty of the manipulation will vary almost in the same ratio as the tension of the wire, and will often impose upon the signalman a useless amount of work, and will make him accustomed to an increase of resistances which may be very great without causing any anxiety as to the results, considering them due to natural or abnormal circumstances. On the other hand, the length of the transmissions ought not to exceed 1,775 ft. when points are to be moved, but will almost always be more when distant signals are to be operated. It will, therefore, be very often necessary to use a wire more than .2 in. in diameter, and thus considerably increase the disadvantages which have been pointed out above. Furthermore, as it is prudent for signal work to use no wire except that of a very high resistance, and one which is, therefore, high priced, and as the construction of compensators is very simple and inexpensive while their operation is positively certain, a large part of the expense incurred by the use of compensators will be balanced by the saving obtained in transmission wires. We are, therefore, of the opinion that it is necessary—

1. To use transmission wires that are as light as possible, and we have selected for our own purpose cast-steel wires 1.3 in. in diameter, which have a breaking strain of 90,000 lbs. per square inch of section and a very high limit of elasticity.

2. To provide suitable compensators for most lines.

But it is possible to dispense with the use of compensators when it is desired simply to bring the manipulation of a certain number of independent points, which are near each other and at short distance from the point of operation, to a central platform; and in this case it is well to regulate the tension of the wires three or four times a year in order to lessen the lost motion. When a lever is moved the strain which is put upon it is not transmitted directly to the apparatus to be moved. This strain must first overcome the inertia of all the elements of the transmission and overcome all friction and all resistances. An increase of tension is caused in the liquid conductor producing an elastic elongation, which is generally called the lost motion. This latter increases with the distance of transmission, the weight of the parts, the distance between the supporting points of the wire and the various stronger resistances. The stroke at the point of attachment of the wire to the manipulating lever ought, therefore, to be equal to the useful stroke of the apparatus to be moved, increased by the lost motion and a certain excess for putting the lever in the stop notch. Theoretically, it is possible to guarantee a good action of the apparatus, since it will be sufficient to vary the stroke of the lever according to the necessities of the case; but practically this is not so with the necessities of construction, interlocking, etc., that are required to give the operating levers a uniform and constant stroke. Then, in certain cases the lost motion may exceed the highest admissible limit. It is true that, in considering the location and construction of the transmitting parts, and the different details in laying out the supports for the wires, etc., it is possible to diminish the inertia as well as the passive resistances a great deal. Thus, for example, in order to carry a transmission wire we have obtained a very low price for stamped steel pulleys which only weigh about .6 lbs., in which the diameter of the axis of rotation is to that of the circle over which the wire rolls in the very favorable ratio of 10 to 145, the weight of which does not rest upon the wire. Furthermore, for sudden changes of movement we find that we can replace chains by steel cables, which are very flexible and pass over pulleys of large diameters carefully mounted, etc. But whatever we may do, the transmission and the manipulating apparatus always offers a certain resistance to motion, and this resistance will vary greatly for two transmissions of the same length, but of different contour. We have, therefore, never been able to entirely do away with the lost motion. Nevertheless, if everything works normally, it is possible in many cases to abridge this lost motion by keeping it within the admissible limits of the actual stroke of the operating lever. In order to accomplish this the stroke of the operating parts of signals and points in the Asser & Thorel, Marti, and State Railway apparatus has been divided into three periods: unlocking, movement and relocking, and the two end periods have been given greater or less proportions. But when for any cause whatever the transmission does not act normally, especially when the wire is caught, this arrangement will not suffice to insure a satisfactory action. In fact, if in a similar case the signalman should continue to haul on the transmitting wire he would stretch this wire, and might very frequently set his lever in the stop notch. He would, however, be compelled to exercise a supplementary effort proportionate to the length of the stroke remaining for the normal motion of the lever; but whatever the cause might be, the strain would be less as the wires were smaller, the distance longer, and the leverage of the operating parts greater. But, on one hand, in order to facilitate the movement under normal conditions, it is desirable to use wires as light as possible and operating levers as powerful as possible. On the other hand, even for small stands the length of transmissions will frequently exceed 3,000 ft. Therefore the signalman would frequently, by a very slight supplementary pull, be able to stretch the transmitting wire sufficiently to set the lever at the end of its stroke, and thus falsify the play of the interlocking arrangements.

The elasticity of the wires constitutes a serious cause of danger which cannot be suppressed, but it is possible to guard against injurious action. For this purpose we have also divided the total stroke of the operating parts, properly so-called, into three practically equal parts, so as to give as great importance as possible to the two extreme periods during which the unlocking and locking is done, and upon which the positiveness of the action depends. We have, at the same time, so arranged our interlocking apparatus as to do all of its work during the first of these three periods—that is to say, before any change has taken place in the position of the points and signals. These two precautions are, however, insufficient in our opinion to entirely do away with the danger due to the elasticity of the transmitting wire, and we have, therefore, adopted for our operating levers a special type of

* Bulletin of the International Commission of the Railway Congress.

construction and operation which constitutes one of its peculiarities, and one which has been perfectly satisfactory to us and will be described later on.

The third cause of disturbance which we have alluded to—namely, the final rupture of the wire—ought to receive most careful consideration. In fact, if we do not take special precautions on this point, the breakage of the return wire may have the effect of keeping the signals to track clear. If the distance is long, and if the first period of the stroke of the moving parts is relatively small, it would be possible for the signals to be set at clear or in a doubtful position, or a point might be slackened off and even set for the opposite track. We have, therefore, so arranged our operating details that in case of the breakage of a transmitting wire, the signals are immediately and automatically brought to danger, and the points are held immovably in the position which they occupied at the moment of the breakage of the wire; so that if the wire which moves a point breaks before the signal in connection with it has been set to clear, no danger can result therefrom. Finally, the signalman is immediately and automatically notified of the breakage of the transmitting wires, and he cannot move any of his levers which act in conjunction with the line that is out of order until it has been repaired.

The operating parts, properly so called, and especially those of the points ought also to satisfy certain special conditions. Thus, for example, while the stroke of the levers is kept constant, it should be possible to easily and quickly vary the opening of the points and remedy any slight defects inherent in the manufacture and setting up, the spreading of the track, or the stretching of the wire and the connections, etc. All whipping of the points on the passage of the trains should be done away with. The points should be fitted so that they are held by their feet up against the rail in such a way that breaking or injury to an important part would not cause any damage to this particular point. In some installations it is necessary to set up between a point and the signal which protects it such an interlocking that when the signal has once been set to clear, the position of the point cannot be modified until it has been passed by the train for which the signal has been set to clear, and the latter has been brought back to danger. Whatever this arrangement may be, it should be possible to correct it for anything which is excessive.

Finally, it may be necessary to provide some points with an auxiliary which prevents them from being changed in position during the passage of a train. This is especially the case where an important point is located at too great a distance from the operating lever for the signalmen to be positively certain at all times whether it is thoroughly locked in position.

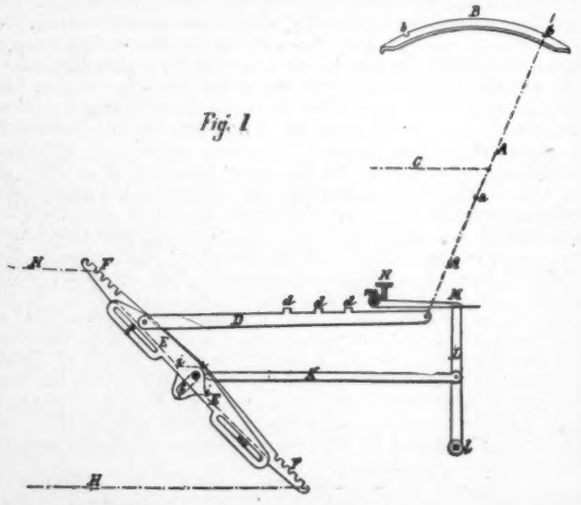


Fig. 1

Operating Lever.—Our operating lever is formed of a rectangular bar of iron *A*, fig. 1, turning about a horizontal axis *a*; its movement is guided by quadrants fastened to the casting *B*; it can be moved and set into its two extreme positions by means of the two stop notches *b b* that are made in the quadrant. The rod *C* connects the lever with the interlocking parts, which are carried on a horizontal table located beneath the floor of the cabin.

The operating lever does not act directly upon the two transmitting wires, but is attached to them by a combination of pieces including: 1. The rod *D* carrying three lugs *d*; 2. An equalizing lever *e*, which turns about a horizontal fixed axis and is pivoted to the rod *D* and has two buttons *E*, by which the distance which separates them from the axis of rotation may be varied at will; 3. A false balanced lever, *F*, having an elongated slot, *F*, at its center, through which the pivot-pin of the lever *E* passes; it rests against the two buttons *E*, and at each end one of the transmission wires *H* is attached; finally there is the cam *i i i*, against the center of which the end of the fork *K* rests; 4. The fork *K* sliding at one end around the axis of rotation of the balanced lever, and pivoted at the other end to a crank lever, *L*; the latter is at the same time keyed upon a horizontal rotating shaft, *l*, and supports by means of the step *M*, which moves around its shaft *m*, a transverse bar, *N*, called the locking-bar.

This arrangement of parts may seem somewhat complicated, but I wish to remark that all the parts which I have just cited are interchangeable and identical one with the other.

Under normal circumstances the tension of each of the two wires of one transmission are practically the same. The false balancing lever *F* rests upon the two buttons *e* and transmits the movements of rotation given to the balanced lever *E* by the rod *D*; but if for any reason one of the two wires of transmission cannot follow the movements of the other, the difference between the tension of the two wires becomes considerable and the equilibrium is broken; the false balancing lever *F* then turns about one of the buttons *e*, its cam, *i i i*, moves out from the axis of rotation and pushes against the fork *K*. The crank *L* then turns, sets the foot *M* free; finally the locking-bar *N* falls, and by means of the lugs *d* locks and fastens all of the connections controlled by *D*.

By moving the buttons *e* more or less, the sensitiveness of this arrangement can be regulated at will, and by giving the locking-bar *N* a suitable length it renders absolutely immovable all the levers which depend upon one another, so that the breaking of a wire produces the same effect as the locking of that wire; its action is felt immediately without its being necessary for the signalman to make a trial of an interlocking lever.

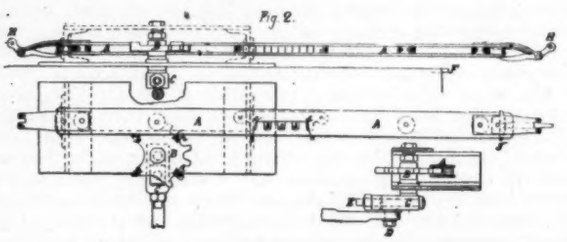


Fig. 2.

This method of operation gives every possible security, not only because the sensitiveness of the balanced levers can be regulated at will, and the signalman notified of every disarrangement of the transmitting parts, but also because the rupture can have no injurious results, while the signalman is notified that there is some danger to look out for. For example, when snow is on the ground each movement of the eccentric banks up a certain amount of snow in between the points of a switch and the main rail. When it has been packed to a sufficient thickness and hard enough so that the point begins to bend, but long before this wedging out will be at all dangerous, the leading wire has such a strain upon it as to prevent the operating lever from dropping down into the stop notch, thus increasing the resistance, and the locking-bar *N* then rigidly fastens all the parts, so that there can be no motion whatever. Not only is the signalman prevented from causing any disarrangement of the signals, but he knows what line is giving the trouble, and consequently examination and repairs are very easy.

Finally, we would say that an accessory arrangement permits the locking-bar *N* to be easily raised, and all the parts to be set back into their normal arrangement.

Detail for Operating the Points.—This detail includes two principal parts, *A* and *B*, fig. 2. The part *A* is composed of two bars of iron riveted together and held parallel to each other by four circular separating pieces and by a part of the rack *a*. This part of a rack is placed exactly in the center of the length of *A* and beneath a notch, *b c d e*, cut into the upper bar. Part *A* has a horizontal movement which is guided by two chairs fixed upon an iron ground plate, and its stroke is limited by the lugs *g* at the ends of the bars.

The part *B* is the pinion toothed over one-half of its circumference and keyed upon a vertical shaft. The teeth, according to the position occupied by *A*, slide between the two bars and mesh in with the teeth of the rack. Its upper face carries four projections *h h i i* placed at the level of the upper bar of *A*.

When the part *A* is at rest in one of its two extreme positions, two of the projections, *h i*, rest against the upper bar and hold the pinion *B* immovable. When the part *A* has made about the first third of its stroke the first tooth of the rack meshes in with the first tooth of the pinion, and the projections *h i* are opposite the notch *b c d e* in the upper bar, and are therefore set free; the pinion *B*, which is thus rendered free, takes on the movement of the part *A*, and during the two-thirds of the stroke of the latter makes a turn through 180°. At this point the engaging teeth again separate and two other projections, *h i*, of the pinion *B* come up against the straight part of the upper bar, while the pinion *B* is once more held fast. The crank *C*, keyed to the shaft of the pinion *B*, shares the fixedness or the motion of the latter, and describes a half revolution. From the pin *D* of this crank a connection is made to the end of the tie-bar, which gives motion to the points. The pin *D* can be set by means of the screw *E* in the crank, and the throw of the points be varied at will, leaving that of the other parts unchanged; in this way it is possible, when so desired, to bring the points in immediate contact with the rails without exercising any pressure upon them. The rigidity of the pin *B* and the slight distance at which it is set from the track moves the points at once. The transmitting wires are fastened respectively to the two ends of the part *A*, to which they communicate their motion. If the whole had been put together by a simple connection, the breaking of the water conductor would have the effect of giving a sudden motion to the operating parts. If the transmitting wire is not provided with a compensator, the point would be apt to be moved in consequence of the tension of the leading wire; if the transmitting wire is provided with a compensator the position of the point will be completely reversed. There is one source of serious danger which we have done away with by providing the part *A* at each end of the spur *H*, which turns about a horizontal shaft and to which the transmitting wire is attached, with a spring having a constant tendency to push the spur down. The force of this spring is so regulated that when the transmitting wire is intact the spur occupies the position indicated in the engraving, and the part *A* can move freely. In case of the breaking of a transmitting wire the corresponding spur is immediately pushed down and drops under the lug *F*; the part *A*, therefore, cannot move beyond the first third of its stroke, and the position of the points remains unchanged, at the same time the locking-bar of the operating lever puts it out of action. The play of the interlocking parts to any point cannot be falsified by the breaking of a transmitting wire, even if this breakage should occur after the corresponding signal has been set to clear. Furthermore, the signalman has been notified of the breakage of a transmitting wire.

(TO BE CONTINUED.)

RÉSUMÉ OF ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN FOR ONE YEAR.

ONE year ago this month we began the regular publication of those railroad accidents that resulted in the death or injury of an engineer or fireman. With our issue for March we completed the record of the first twelve months, and an appalling record it is. That it is incomplete goes without saying, for our main source of information is the published accounts in the daily papers, and there must have been some fatal and many minor accidents that were never reported. In reviewing this list of horrors, we find that during the year there were 450 accidents resulting in the death of 108 engineers and 114 firemen, and in the injuring of 251 engineers and 223 firemen, giving an average of 37½ accidents per month. There has been no epidemic of accidents, but a steady run, and the number reported for each thirty days has been remarkable in its uniformity. The terrible accidents that were reported during the summer in connection with the World's Fair excursion trains neither raised nor lowered the average of accidents to engineers and firemen, but were merely incidental to the number that occurred with astonishing regularity. The following is a *résumé* of the accidents occurring between March 1, 1893, and March 1, 1894:

Attacked by strikers	2
Blowing out of cylinder-head	1
" " plug	1
" " safety-valve	1
Boiler explosions	29
Breaking of wrecking apparatus	1
" through trestle	1
Broken axle	2
" connecting-rod	3
" coupling-rod	6
" crank-pins	1
" eccentric-rod	1
" rails	4
" side rods	2
" truck	1
Bursting of flue	1
" " gauge glass	3
" " oil glass	1
" " pipe	1
" " steam pipe	3
Cattle on track	9
Caught between cars	2
" " locomotive and engine house	1
" by hot pipe	1
Collisions	148
Defective bridges	8
Derailments	50
Falling of tool-box lid	1
" or jumping from engine or car	37
Gas explosion in car	1
" " from furnace door	3
Hand crushed	1
Jumping on engine	1
Land slide	5
Lost tire	1
Obstruction placed on track	2
Misplaced switches	29
Powder explosion	1
Rail spread	2
Run over	6
Runaway engine and train	9
Running into snow bank	2
Shot by train robbers	2
Struck against backboard	1
" by coal	1
" " obstruction	17
" " train	16
Thrown from train	1
Tunnel roof falling	1
Uncoupling hose	1
Unknown	21
Washout	4
Total	450

Referring to this list, we find that collisions are by far the most prolific sources of danger, there having been 148 during the year; next comes derailments, at 50; falling from engine or car, 37; misplaced switches, 29; boiler explosions, 29; struck by obstruction, 17; cattle on track, 9; runaway engine, 9; and unknown, 21. Of these principal sources of accident it must be gratifying to the mechanical departments to note how few can be laid at their own doors; while the precautions taken by the operating department through the policy of the board of directors make a bad showing in the 147 collisions and 29 misplaced switches, while the road department should be held responsible for the injuries to men who were struck by obstructions or hurt by cattle being upon the track. Taking the accidents as they stand recorded, we should place the responsibility about as follows:

Mechanical department	60
Operating "	178
Personal negligence	69
Road department	104
Unassignable	33
Violation of criminal laws	6
Total	450

Thus, out of 342 accidents which are directly traceable to one or another of the departments of the railroads, the mechanical department is responsible for 60, or about 17½ per cent. of the whole. The predominance of collisions over every other form of accident simply means that suitable provision has not been made for the protection of trains; in short, that the block system is not considered necessary. As a matter of investigation, it would be interesting to learn just what these 148 collisions have cost, and how much this cost would be raised by the other collisions in which neither an engineer nor a fireman were hurt, but where cars were reduced to scrap or passengers brought into a damage-claiming condition.

Block signaling costs money, but when it is established the company has something tangible to show for its outlay;

while with a collision the only assets available is a collection of more or less worthless scrap and the quit claim signatures of the victims.

We have announced that the object of publishing the monthly list is "with the hope that such publication will in time indicate some of the causes of the accidents," and that we desire some indication of "the causes and cures for any kind of accidents that may occur." The first year of this publication seems to us to go a long way toward indicating some of these causes, and the cure for this one type is easily found in the prevention of all attempts to make trains pass one another on a single track. The absolute block system, whether it be applied in one of the common systems on a double track, or with the staff system on the single track would seem the plain, common-sense solution of the difficulty.

The operating department should also be called into account for the mistakes of its subordinates, and the rectification of such mistakes and the prevention of their repetition is so largely a matter of discipline, and discipline is so largely dependent upon the personal equation of the man in command, that we have no suggestion to offer except that a high standard of obedience to the rules of the company be demanded, and that the service be rid of men prone to make mistakes.

The road department comes in for its share of the responsibility through its neglect to observe proper precautions in construction and repairs. There is no possible excuse, for example, that 17 men should have been killed or injured by being struck by obstructions placed so near the rails as to strike a man leaning from a cab window. If tracks are so arranged that a signal-pole comes dangerously near the rails when placed in the most desirable position, that is no excuse for not putting it in a less desirable place and avoiding even the appearance or possibility of danger. Cattle are run over in innumerable quantities, but as they are almost always struck while standing, they rarely cause an accident in which any one is hurt; but the spreading and breaking of rails, landslides, defective bridges, and the like, simply mean defective watchfulness. Not that the utmost vigilance will always avert a disaster, for the damage may be done immediately after inspection, as in the case reported in March, where, on a California road, an engine crossed a bridge on an inspection trip, and on returning a few minutes later for its train, went down, killing four men; the bridge foundations having been undermined between the two passages.

Coming to the mechanical department, with its 60 accidents, of which 29 were boiler explosions, we find it difficult to point out just where reforms should begin. Of course the boiler explosions mean either careless inspection or careless handling. In a recent report made on the boiler explosions of a certain road, out of 14, 13 were shown to be directly attributable to carelessness on the part of the enginemen. A boiler does not explode unless it is too weak to withstand the internal pressure; and if it is too weak the head of the department should know it. When a boiler comes in for repairs with 84 staybolts broken and only four reported at the last inspection one week previous, there is something rotten in Denmark; yet that is an actual case of which we have personal knowledge. Engineers are dealing with a tremendous power, and the careful man fears it more and more as the years roll be. Careful, systematic inspection by men of known competency is respectfully suggested as one of the remedies to be applied in lessening the number of these accidents.

Of the other minor accidents, such as the breaking of rods, the cracking of tires, the bursting of water glasses, and the like, it is not probable that a modification of design would help appreciably. Careful inspection should be maintained; but above all the purchasing department should be brought to a realizing sense of the fact that low-priced material means poor material; that poor material means breakages, delays, and expense; and that true economy calls for the best. We have yet to find the master mechanic or superintendent of motive power who was an advocate of poor material; but we know scores who are in a constant state of worriment over the inferior supplies foisted upon them by the purchasing departments. Therefore, a few lessons to the buyers might not be out of place in order to show them that there are irons and irons, and that a metal need not necessarily be suitable for bearings merely because it is yellow and leaves a bad taste in the mouth.

When we come to those cases where men are injured through their own personal neglect, reformation seems a hopeless task. The old saw of familiarity breeding contempt is especially applicable. Men are so in the habit of swinging on and off of engines while they are in motion, and of just allowing a bare clearance between their own bodies and a passing train, that the day is apt to come when the foot slips or the clearance is cut down to the striking point, and a disabled man is the result. The men know the dangers to which they are exposed and to which they expose themselves, and the only wonder is that out of the millions of repetitions of certain movements we have only to record 69 as resulting injuriously.

In reviewing the accident record for the past year, the recommendations that are thereby suggested are that a block system of running trains be adopted wherever it is not in vogue; that the road department look well to the designing and construction of all bridges, etc., and pay particular attention to the location of posts and building, making sure that they are far enough from the rails to be beyond striking distance; that the mechanical department redouble its efforts to reduce explosions by a rigid and systematic inspection, for we take it for granted that the boiler designs are correct, or at least unchangeable, and that the purchasing department look to it that low-grade goods are not bought, even though the discounts be the most attractive in the world.

160-TON CRANE AT HER MAJESTY'S DOCKYARD, CHATHAM.

THE fine crane which we illustrate on page 165 has been erected at Her Majesty's Dockyard, Chatham, by Messrs. Tannett, Walker & Co., Engineers, Leeds. The crane may be considered as a combined steam and hydraulic crane, as the hydraulic system is only used for lifting heavy loads, light loads being lifted by tackle worked by steam power, which is also used in revolving the crane. The crane in question is capable of lifting a load of 160 tons to a height of 50 ft., this being done, on the so-called direct-acting system, by means of a hydraulic cylinder fitted with piston and rod. The extreme range of the crane is 75 ft. 3 in., and the height of the jib-end sheave from the quay level is 125 ft. The full load of 160 tons is raised by means of hydraulic pressure, and there is a wire rope with block hook for lighter loads up to 30 tons. The roller-path on which the crane revolves is 45 ft. 4 in. in diameter. As will be seen, the crane is mounted on a massive masonry foundation, to which the roller-path is firmly bolted. The rollers are mounted on a live ring, and, being closely packed, give a good distribution of the load. The framing of the crane is of the most massive character, a very rigid structure being thus obtained. The counterweight is fixed behind the boiler, as shown to the left in our engraving.

The boiler is of comparatively large size—namely, 18 ft. long by 7 ft. 8 in. in diameter, and is of the horizontal type. It supplies steam to three pairs of engines, of which one set pumps the water for the hydraulic cylinder, another set revolves the crane, while the third set works the wire rope tackle used in lifting light loads. After its erection at Chatham, the crane was tested with a load of 320 tons, which it carried without difficulty. The total weight of the structure is, we may add, about 500 tons.—*Engineering.*

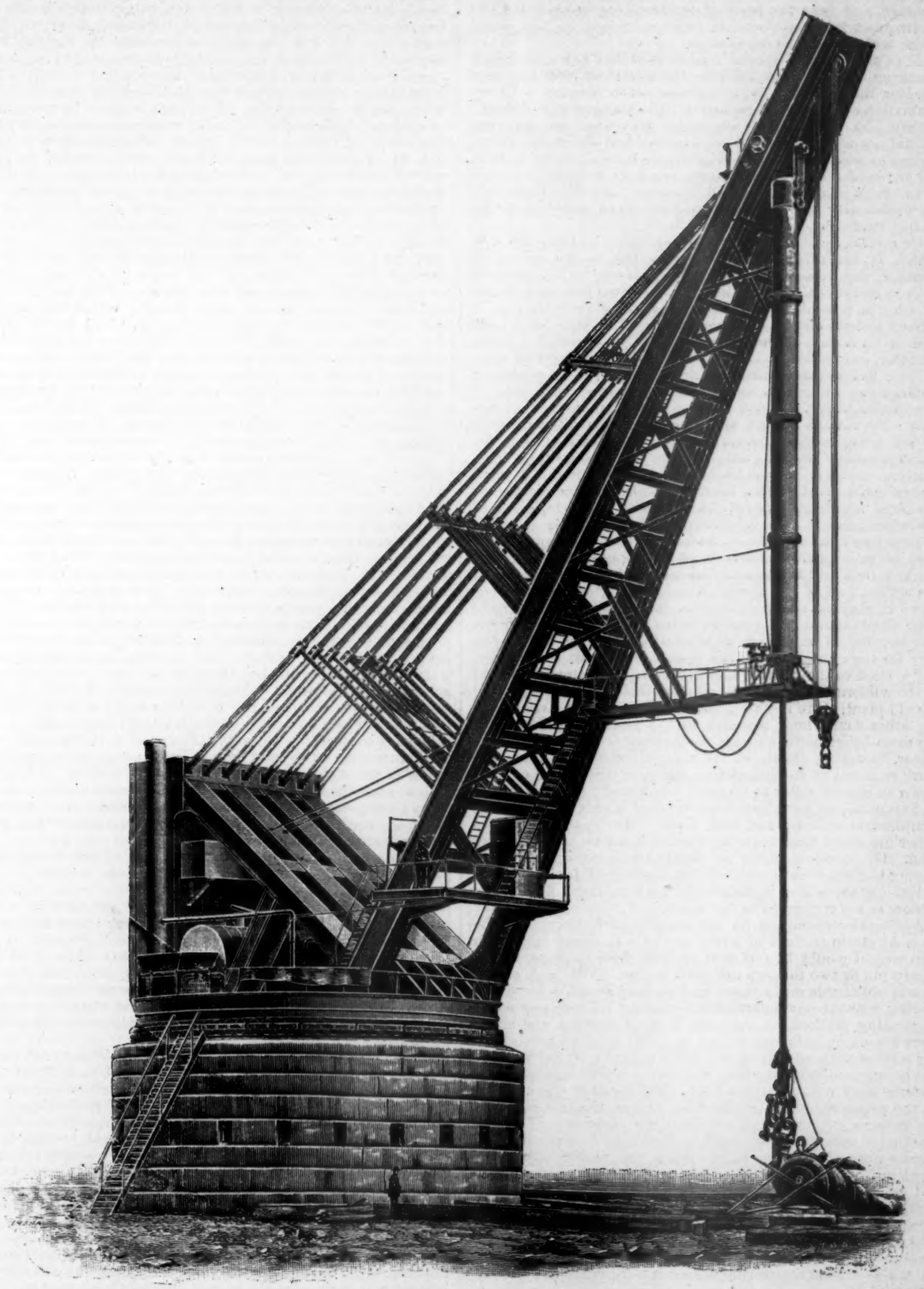
ELECTRICAL TRANSMISSION OF POWER IN FACTORIES.*

BY ALEXANDER SIEMENS, M.I.C.E.

IN order fully to appreciate the importance of distributing power in works by means of electro-motors, a short statement of their principal features will not be out of place. Electro-motors are of simple construction, they require little attention, and are free from waste products; they require light foundations, will run at constant speed when properly wound, they consume energy in proportion to the work they do, and are easily adapted for driving any kind of machine or tool.

They consist essentially of two parts, the magnets and armature, the latter being the only moving part. It is evident, therefore, that we have little to fear if we can manage to build the armature in such a substantial manner that it runs without giving trouble. The magnets being stationary, it is only necessary to provide good enough insulation, and that presents no difficulty. The construction of an armature may be more clearly understood by considering this sample one. It consists of a steel spindle on which is strung a number of soft iron disks, each stamped to fit over a key which is sunk into the spindle, thus ensuring good driving. The conductors are copper bars, either solid or made up of strands of wire, according to the size of the machine. They are laid round the circumference and connected at one end to the commutator;

* Abstract of lecture delivered before the Birmingham Association of Mechanical Engineers.



100-TON CRANE AT HER MAJESTY'S DOCKYARD, CHATHAM.

at the other they are joined up by curved end connections, a compact arrangement, taking up far less space than the old method of wire winding. The bars are insulated from one another, and from the body of the armature, space being left at frequent intervals round the circumference for hard wood pegs, which drive the conductors.

Fine steel wire of special quality (120 tons per square inch breaking strain) is wound over the whole at intervals, thus keeping the bars from flying outward when running. An examination of this armature and a little thought will, I think, satisfy you that there is no reason why such an armature should not be a thoroughly good mechanical structure. With regard to commutators and brushes, we have all heard tales of the ravenous way motors consume brushes; brushes of copper wire, strips and gauze, as well as carbon, are alike devoured. Now, this may happen from either of two causes—bad design or bad treatment.

Of course, good treatment will not make a motor run well which is radically wrong in design, but in the matter of brushes, and motors generally, the proverb, "Cleanliness is next to godliness," applies literally. Let me give an instance of what is possible in the direction of keeping down cost of repairs and attendance. A few days ago I accompanied Lord Kelvin on a visit of inspection to the City & South London Railway, our object being to look at the armatures of some electric locomotives which my firm built for their passenger traffic some 15 months ago. These armatures had been in continuous work, and had received the usual amount of care only; they were hauled up for examination after running 26,000 miles without repair. We were informed that the brushes we saw were the original ones supplied with the locomotives, the spare set not having yet been required. A small transmission plant erected by the late Sir William Siemens at his house near Tunbridge Wells will serve to illustrate two of the advantages I have enumerated—viz., the little attention required and the absence of waste products. A pump, situated several hundred yards from the house, was formerly worked by a small steam-engine and boiler; these occupied the whole time of one man. A small electro-motor was put down in place of the steam-engine, and supplied with current from the dynamos in the main engine house. This motor has run now for 14 years very satisfactorily, and it is only necessary for the gardener who has charge of it to make one journey a week to the pump-house to fill the lubricators. Instead of the wilderness of ashes and clinkers that accumulated round the old plant, there is now a garden. We cannot avoid making ashes somewhere, but now all the ashes are produced at the main boiler-house and are easily dealt with. The electro-motor, therefore, stands in the unique position of doing the work required of it without fuss, noise, or dirt. You can put down an electro-motor to do work temporarily where it would be impossible to have any other type of motor, owing to the complicated exhaust and feed pipes. Having to light up a boiler fire every time water is wanted is a very uneconomical plan. Of course by using an electro-motor we do not avoid having to light fires altogether, but the cost of fuel and labor of lighting those fires is distributed over as many power consumers as are connected to the mains.

Again, electro-motors do not require such heavy foundations as steam-engines of equal power. In many cases their own weight would be sufficient to hold them in place, with a steady pin or two to keep the shaft in line. The high or low speeds obtainable make these motors very suitable for direct driving without any intermediate gearing. There are no reciprocating motions, as there are in most engines, and armatures are easily balanced to run at 1,000 or more revolutions per minute without vibration. With regard to speed, nothing can be more satisfactory than the way a shunt-wound motor governs itself with a varying load. The speed is just a matter of the pressure on the terminals so long as the load is within the motor's capacity, and provided the mains are of such a size that a variation from light to full load does not produce a great drop of pressure in the mains, the motor will run at practically constant speed. This fact we have proved over and over again at Woolwich. Perhaps the most successful application of electro-motors was when we substituted them for small steam-engines, which used to drive our india-rubber rolls. Formerly we could never get anything approaching steady running; a piece of raw rubber would pull the engine up, while no load meant running away. Now we can cram in rubber of all sorts, and the motor takes just enough current to make it give out the requisite power at the proper speed. This feature will be at once appreciated by any one who has to do with such intermittent work as sawing, etc. Although shunt motors run at constant speed, it must not be thought that the speed of any particular motor is absolutely fixed. It is far easier to vary speed with an electro-motor than with any other kind of engine. For varying speed we provide a resistance switch in the exciting circuit by which the strength of the magnetic field may be varied, and thereby the motor made to run faster or slower at will. A starting switch is also required. There are two handles on the switch, interlocked in such a way that it is impossible to interrupt the exciting current while current is in the armature, or to complete the armature circuit without first closing the exciting switch. The construction of this switch should be noticed at each place where the circuit is broken. The spark is taken by two pieces of carbon. This keeps the metal contacts clean and in good condition. As before stated, a motor takes current in proportion to its load, thus measuring the current forms, an easy way of estimating the power taken to drive any tool. The motor is connected to mains carrying a certain pressure; the product of this pressure, and the current measured in the ordinary units for which commercial instruments are calibrated, divided by 746, gives the electrical horse power. The power may be absorbed in a brake, or transmitted to the machine through a dynamo meter, and the brake H.P. corresponding to any electrical power is at once known. This enables us to put down a motor for any piece of work which will just do that work comfortably, being neither too small for its work nor yet wastefully large, for a motor or engine working below its proper load is always more or less inefficient. An examination of the current indicator—which registers continuously—serves the same purpose as taking an indicator diagram from a steam engine, only it is infinitely quicker. It will tell you if the motor is fully loaded or overloaded; if anything goes wrong and fails to advertise itself, the ammeter will tell you.

Every manufacturer knows that a great deal of his engine power goes in keeping the shafting and pulleys running, and what a small proportion of it is utilized at the tool points. The conditions aimed at in electrically-driven plant, and which will go a long way toward cheapening manufacture, are to supply each tool with just enough power to do its work, and to keep it from absorbing any when not in actual use. In making extensions it is often found that shafting is too weak to bear any additional strain, having been put down as small as possible for the sake of cheapness or to save weight. With electric motors there is no such trouble; each tool having its own motor, it is only necessary to provide mains of sufficient section to carry the ultimate load, or even less at first, as it is a far simpler thing to lay down another main alongside the existing one than it is to thicken up a shaft. Unlike a heavy shaft, a large cable does not involve a heavy driving cost; a small motor may be driven through a large cable, and yet the efficiency of working be every bit as good as if that cable carried current up to its safe limit. Each motor added produces a loss in the cable proportional to the work it does. It is difficult to alter the speed of individual machines when driving by belts; some such arrangement as cone pulleys or step cones must be used. On the other hand, electro-motors are well under control in this respect.

Having now dealt with the advantages of the electric system, and the disadvantges of the old, I will proceed to describe briefly the generating station and plant in use at Woolwich. The boilers, three in number, are constructed for a working pressure of 120 lbs. per square inch; they are hand-stoked two-flue multitubular boilers, of the "gunboat" type. The engine and dynamo-room, which is only 42 ft. × 30 ft., will accoommdate four sets of generating plant; at present only three are erected, and the fourth set is quite ready to put down. The dynamos are H.B. 24/36 shunt wound, each giving normally 1,500 ampères at 120 volts when running at 350 revolutions per minute.

Two of the dynamos are coupled direct to Willans III. compound non-condensing engines, indicating 300 H.P. at 350 revolutions. The third is coupled to a Belliss compound closed engine, also indicating 300 H.P. at 350 revolutions.

From the dynamos the current is led through the main switchboard, and is measured by the ammeters, the total amount of electrical energy supplied being measured by the electricity meter. Pressure is continuously indicated by a volt meter connected across the distributing bars. The switching arrangements are such that all the machines may be run in parallel. Current is distributed throughout the works by means of underground cables. There is first a copper conductor consisting of strands of wire of suitable size for the current; over this is lapped jute impregnated with insulating compound; next comes a continuous lead pipe to keep out damp, and over this the wore jute. Mechanical protection is afforded by hoop steel, wound spirally, and lastly an outer coating of jute to protect the steel from rusting.

These heavy cables can only be made in lengths of 180 or 200 yds., so it is necessary to join the ends of these lengths together.

The ends of the cable are brought together through a copper sleeve, into which they are soldered; the two halves of the jointer are then bolted together round the joint, and insulating oil is poured in through holes in the cover, which are afterward stopped by screw plugs.

Stuffing-boxes at each end keep out damp. The cables are laid straight into the ground, without any culverts or other protection than the armoring, and long experience proves that nothing could be more simple and satisfactory. Wherever a cable enters a workshop it goes first to a dstributing board, fitted with a controlling switch and electricity meter; from there it branches to the requisite number of circuits, each circuit being protected with a safety fuse.

I now come to the all-important question of cost, and will proceed to give the results of some carefully conducted tests made on the existing plant at Woolwich. In the following results the coal used in keeping steam during meal times is included, but not the coal used in lighting the boiler fires.

		1	2	3
Number of test....				
Date.....		Feb. 23 to 28.	March 1.	March 3.
Time started.....		11.45 A.M.	7 A.M.	5.57 A.M.
Time stopped.....		5 P.M.	5 P.M.	5 P.M.
Total boiler hours.		46.6	10	11.033
Total engine hours.		41.78	8.567	9.617
Coal, description.. Welsh medium quality, 15s. per ton, delivered in bunkers.				
In Board of Trade units.	Weight used.....		27418	5488 6720
	Total output.....		4899	983 1287
	Mean hourly output.....		117.27	114.73 133.66
	Pounds of coal per unit....		5.596	5.584 5.224
In electrical H.P.	Total H.P. hours.....		6567.1	1317.5 1724.6
	Mean effort.....		157.2	158.3 179.15
	Pounds of coal per H.P. hour		4.157	4.165 3.897

Mean result, 4 lb. of coal per electrical H.P. hour.

The plant in the above tests was not working under the most favorable conditions, not being fully loaded; when fully loaded and condensing still lower consumption may be reasonably expected. Three indicator cards were taken from No. 3 engine (Willans) on March 2, and the electrical H.P. was measured simultaneously. In the three cases we found respectively 84.2, 84.0, and 83.7 per cent. of the indicator H.P. as available electrical H.P. at the main switchboard.

The cost of an electrical H.P. hour works out as follows:

Coal, 4 lbs., at $3.75 per ton.....	0.75 ct.
Wages, stokers, trimmers, engine drivers, laborers, electrical assistant (half time), laborer (one-third time), switchboard boy....	0.08
Feed water.....	0.0500
Oil and Waste.....	0.0292
Removing ashes.....	0.0092
	0.9184
Cost of a Board of Trade unit.....	1.090 ct.

In this statement of cost it is assumed that the station is in full work, three boilers and three engines each giving 240 electrical H.P. This only represents 80 per cent of the indicator H.P., and we have obtained over 84 per cent., so that the cost given above is rather overstated. Taking the cost of an electrical H.P. hour at .8 cent and working 10 hours a day for 309 days a year, each electrical H.P. at the main switchboard costs $24.00 per annum; 70 per cent. of this is available as brake H.P. at the spot where it is used, so each brake H.P. costs $34.29 per annum.

We commonly find $48.66 given as the yearly cost of a brake H.P. Assuming this to be fair, we have still a margin of $13.98 to pay for repairs and depreciation, a far larger sum than we are ever likely to require. At present we have working eight motors of 40 brake H.P., four of 20, two of 15, three of 10, one of 8, two of 5, and two of ½ H.P., for driving ventilating fans, making a total of 479 H.P. Three more are being put down, one of 40 and two of 20, and nine more are in hand, seven being of 75 H.P., one of 40, and one of 30. We also anticipate early extensions amounting to another 350 H.P., bringing up the total to 1,504 H.P.

The maximum normal output of the generating station working at 84 per cent efficiency is 1,008 electrical H.P., or 706 brake H.P. at the motors. This may seem a small proportion of the possible total, but we believe it is sufficient to meet the ordinary loads, and extensions in the generating plant are easily arranged. Of course in some factories it might be necessary to have generating plant capable of working all shops at full load.

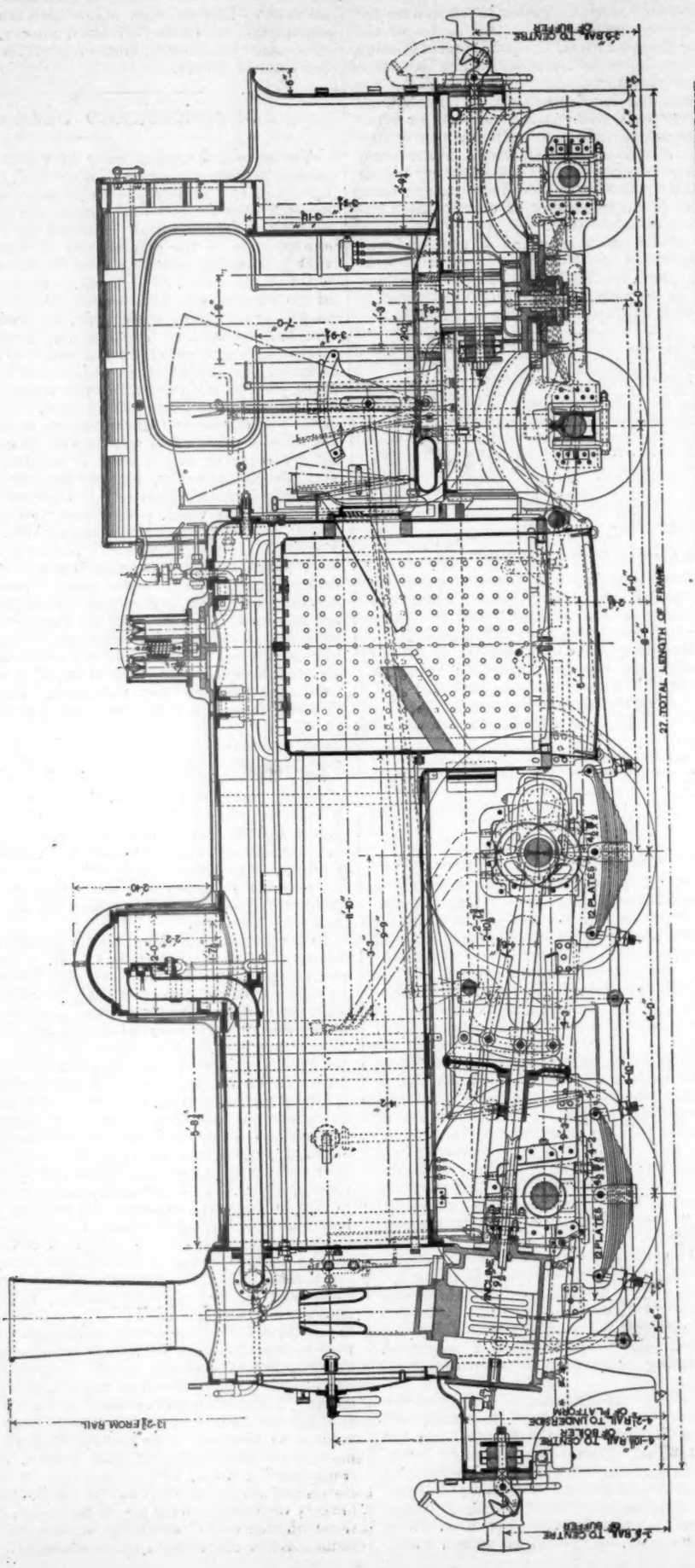
So far I have only dealt with the advantages of transmitting power electrically in large works. I believe, however, that small industries will benefit largely in the future from the establishment of central power stations in towns and cities, from which stations small manufacturers can get a supply of current at a reasonable price, and avoid the trouble of looking after a small steam or other engine. Such a state of things would be going backward in a certain sense, but it would be going back to a far happier state, for the skilled artisan would be able to take in work at his own small shop and have the satisfaction of feeling his own master, while he would not necessarily be debarred from competition with the larger works for want of power.

UNCONSIDERED USES OF WOOD.

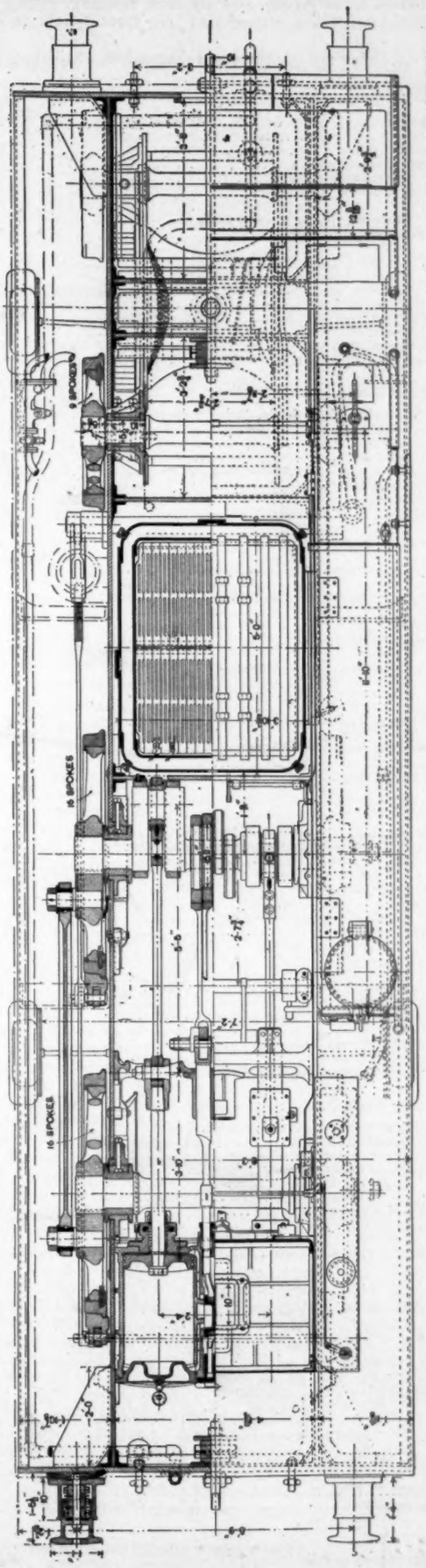
THERE are countless ways in which wood is being consumed, besides the larger uses for fuel, building purposes, and the like; and that in the aggregate these unconsidered uses amount to a serious drain upon the forests, while little or nothing is done to insure a supply for future demands. The enumeration of the special uses of wood in the arts forms a very interesting chapter. One of the principal uses of the wood of the holly, dyed black, is to be substituted for ebony in the handles of metal teapots, etc., and the strong straight shoals, deprived of their bark, are made into whip handles and walking sticks. The lime-tree forms the best planks for shoemakers and glovers upon which to cut their leather, and is extensively used in the manufacture of toys and Tunbridge ware, and by the turner for pill boxes, etc.; and the inner bark is made into ropes and matting. The sycamore furnishes wood for cheese and cider presses, mangles, etc., and when the wooden dishes and spoons were in common use they were mostly made of this wood. It is now used also in printing and bleaching works, for beetling beams, and in cast-iron foundries for making patterns. The yew is used by the turner and made into vases, snuff-boxes, and musical instruments; and it is a common saying among the inhabitants of New Forest that a post of yew will outlast a post of iron. Where it is found in sufficient quantities to be employed for works underground, such as water pipes, pumps, etc., the yew will last longer than any other wood. Gate posts and stakes of yew are admirable to wear, and in France the wood makes the strongest of all wooden axletrees. Of the beech are made planes, screws, wooden shovels; and common fowling-pieces and muskets are also stocked with it, and beech staves for herring barrels are not unknown. The sweet or Spanish chestnut furnishes gate and other posts, railing, and barrel staves, hop poles, and other such matters, such as strong and good charcoal, though scarcely equal to that of oak for domestic purposes, but considered superior to that of any other for forges.

Hornbeam is the best wood that can be used for cogs of wheels, excelling either the crab or the yew; but its application in this manner is about at an end. As a fuel it stands in the highest rank, emitting much heat, burning long, and with a bright, clear flame. In charcoal it is highly prized not only for culinary purposes and the forge, but also for the manufacture of gunpowder, into which, on the Continent, it enters in large proportion.

In Russia many of the roads are formed of the trunks of the Scotch pine, trees from 6 in. to 1 ft. in diameter at the larger end being selected for the purpose. These are laid down side by side across the intended road, the thick of one alternately with the narrow end of the other, and the branches being left at the end to form a sort of hedge on each side of the road. When thus laid, the hollows are filled up with earth, and the road is finished, being analogous to the corduroy roads of North America. In Germany casks are made of larch, which is almost indestructible, and they allow of no evaporation of the spirituous particles of the wine contained in them. In Switzerland it is much used for vine crops, which are never taken up, and which see crop after crop of vines spring up, bear their fruit, and perish at their feet without showing symptoms of decay. The uninjured state in which it remains when buried in the earth or immersed in water renders it an excellent material for water-pipes, to which purpose it is largely applied in many parts of France. The butternut is esteemed for the posts and rails of rural fences in America, for troughs for the use of cattle, for corn shovels and wooden dishes. Shell-bark hickory provides baskets, whip handles, and the backbows of Windsor chairs. The pignut hickory is preferred to any other for axletrees and ax-handles. The sugar maple is used by wheelwrights for axletrees and spokes, and for lining the runners of common sleds. Dogwood is used for the handles of light tools such as mallets, small vises, etc. In the country it furnishes harrow teeth to the American farmer, and supplies the harness of horses' collars, etc.; also lining for the runners of sledges. The mountain laurel is selected for the handles of light tools, for small screws, boxes, etc. It most resembles boxwood, and is most proper to supply its place. Bowls and trays are made of red birch, and when saplings of hickory or white oak are not to be found, hoops, particularly those of rice casks, are made of the young stocks and of branches not exceeding 1 in. in diameter. Its twigs are ex-



FOUR-WHEELED COUPLED BOGIE TANK LOCOMOTIVE ON THE LONDON & SOUTHWESTERN RAILWAY. DESIGNED BY MR. W ADAMS, LOCOMOTIVE SUPERINTENDENT.



PLAN OF FOUR-WHEELED COUPLED BOGIE TANK LOCOMOTIVE ON THE LONDON & SOUTHWESTERN RAILWAY. DESIGNED BY MR. W. ADAMS, LOCOMOTIVE SUPERINTENDENT.

clusively chosen for the brooms with which the streets and court-yards are swept. The twigs of the other species of both, being less supple and more brittle, are not proper for this use. Shoe lasts are made from birch, but they are less esteemed than those of beech.

Immense quantities of wooden shoes are made in France from the wood of the European alder, which are seasoned by fire before they are sold. The wood of the locust is substituted for box by the turners in many species of light work, such as salt cellars, sugar-bowls, candlesticks, spoons, and forks for salads, boxes, and many other trifling objects, which are carefully wrought into pleasant shapes and sold at low prices. The olive is used to form light ornamental articles, such as dressing cases, tobacco-boxes, etc. The wood of the roots, which is more agreeably marbled, is preferred, and for inlaying it is invaluable. Of persimmon turners make large screws and tinmen mallets. Also shoemakers' lasts are made of it equal to beech, and for the shafts of chaises it has been found preferable to ash, and to every species of wood except lancewood. The common European elm is used for the carriages of cannon, and for the gunwale, the blocks, etc., of ships. It is everywhere preferred by wheelwrights for the naves and fellies of wheels, and for other objects. White cedar serves many subsidiary purposes. From it are fabricated pails, washtubs, and churns of different forms. The ware is cheap, light, and neatly made, and instead of becoming dull, like that of other wood, it grows whiter and smoother by use. The hoops are made of young cedars stripped of the bark and split into two parts. The wood also supplies good charcoal. The red cedar furnishes staves, stopcocks, stakes, and is also used for coffins.

A few special applications of wood in this country are mentioned, separated into trades—namely, sieves, usually of black or water ash for the bottom and oak or hickory for the circle; whipstocks, white oak; baskets, willow, white oak, and shellbark hickory; picture frames, white pine and sweet gum; saddle-trees, red maple and sugar maple; screws of bookbinders' presses, hickory or dogwood; hatters' blocks, sour gum; corn shovels, butternut; shoe lasts, beech and black or yellow birch.—*Illustrated Carpenter and Builder.*

FOUR-WHEELED COUPLED BOGIE TANK LOCOMOTIVE.

THIS type of engine has been designed by Mr. W. Adams, Locomotive Superintendent of the London & Southwestern Railway, and built at the Company's works at Nine Elms, and is intended for working the lighter suburban and branch traffic of the railway.

As will be seen from the accompanying drawing, the engine has the leading and driving-wheels coupled, 4 ft. 10 in. in diameter, while the back of the engine is carried on a four-wheeled bogie of the "Adams" type, having wheels 3 ft. in diameter.

The cylinders are 17½ in. in diameter with a stroke of 24 in. The tractive force developed is accordingly

$$\frac{17\tfrac{1}{2}^2 \times 24}{58} = 126.7 \text{ lbs.}$$

for every pound of mean effective pressure on the pistons. The cut-off varies from 77 per cent. in full gear to 28 per cent. under usual running conditions.

The boiler pressure is 160 lbs. per square inch, hence the total tractive effort available is about 17,000 lbs. at starting and 11,000 lbs. under ordinary running conditions. The total weight on the coupled wheels with the engine in working order is 66,136 lbs., which, with a coefficient of adhesion of one-fourth, is sufficient to prevent slipping.

The boiler is constructed of steel plates with butt joints, the top of the fire-box casing being flush with the barrel. The mild steel plates are specified to be free from silicon, sulphur, and phosphorus, and to have a tensile strength of not less than 25 tons and not more than 30 tons per square inch with an elongation of at least 23 per cent. in 10 in. The longitudinal joints have inner and outer cover strips with zigzag double riveting. The transverse joints are made with an external weldless ring double riveted to the barrel, the ring being turned to gauge and shrunk on the barrel. The joint between smoke-box and barrel is also made in a similar way with a weldless angle ring.

The rivets, ¾ in. in diameter, are of the best Yorkshire iron closed by hydraulic pressure. They are pitched at 1¾ in.

The fire-box is of copper and contains a fire-brick arch. It is connected to the outer casing by copper stays 1 in. in diam.

eter, 12 threads per inch, pitched at intervals of 3⅛ in. The roof is stayed by eight cast-steel girder stays, the four center ones being slung from the casing. The tube plate, which is ⅜ in. thick at the tubes, is stayed to the barrel by six palm stays. The foundation and fire-hole rings are of wrought iron, and the fire-bars are of cast iron.

The regulator is of cast iron 4½ in. diameter, with a main slide-valve of brass and an easing valve of cast iron.

The dome is of ½ in. boiler plate butt jointed with inner and outer strips single riveted. It is flanged to fit the barrel and double riveted to it with a ½-in. strengthening plate.

The boiler is fitted with a "Ramsbottom" duplex safety-valve.

The frames are of steel of boiler plate quality, 1 in. thick. They are connected under the cab by a strong steel casting to carry the bogie center pin and trasmit the weight to the bogie, the frames of which are of steel 1 in. thick, and stayed together by a strong steel casting which forms a slide to give transverse play to the centre pin, this being controlled by laminated plate springs.

All the wheel centers are of cast steel. One casting in 40 is tested to destruction by dropping weights in order to determine its breaking strength.

The tires are of steel supplied by Vickers & Co., of Sheffield, and are 3 in. thick on tread. They are secured to the wheels with a lip and 1½ in. set screws.

The axles are of steel, and are specified to have a tensile strength of not less than 32 tons per square inch, with an elongation of not less than 25 per cent. in 2 in.

The cylinders are of the twin type, being one casting, and special arrangements have been made for machining them. The steam-ports are 1⅜ in. wide and 14 in. long. The exhaust-ports are 3¼ in. wide, and the bars between the ports 1 in. wide. The slide-valves are of Stone's bronze with recesses on the working faces. The pistons are of cast iron with two cast-iron rings each, each ring being ¾ in. wide and ½ in. thick. The piston-rods are forged from the best cast steel with a breaking strength of 30 tons per square inch. They are packed with "United States" metallic packing.

The slide-bars, one to each cylinder, are of wrought iron, case-hardened, and 6 in. wide by 3 in. deep.

The cross-heads are of cast steel with cast-iron caps and rubbing pieces. The cap is secured to the main casting by ¾ in. bolts, a liner being introduced to permit adjustment for wear.

The valve-motion is of the curved link type, and made of best Yorkshire iron, the working parts being case-hardened. The links are hung from their centers and connected at their extremities to the eccentric rods. The eccentric pulleys are in two parts, and are made of cylinder metal. They are fastened to the crank-axle by keys and set screws. The straps are of cast iron.

The engine is reversed by a lever and sector on the right-hand side of the engine. The reversing shaft is of Yorkshire iron, the levers being forged solid with the shaft. All working parts of the shaft are case-hardened.

The connecting-rods are of Yorkshire iron, and measure 3 ft. 5 in. between centers. The big ends are fitted with straps and adjustable brasses. The small ends are fitted with plain gun-metal bushes forced in by hydraulic pressure.

The coupling-rods are of Yorkshire iron forged solid and milled to an H section, and fitted with gun-metal bushes with white metal strips.

The crank-pins are of Yorkshire iron case-hardened, and are forced into their places in the wheels by hydraulic pressure and riveted over on the inside.

The crank-axle is of the very best cast steel forged solid. All four crank webs are hooped with steel bands 3½ in. × 1½ in., shrunk on. All crank-axles are supplied by Messrs. Vickers & Co.

The engines are fitted with the "Adams" patent vortex blast-pipe, which is successful in softening and utilizing the exhaust steam to obtain a good vacuum in the smoke-box, its effect being equally distributed over the tubes, the lower tubes being thus kept free and their efficiency unimpaired by becoming choked up, as is the case when an ordinary plain blast-pipe is used. Engines fitted with this form of pipe have given economical results.

The engine is fitted with a steam-brake worked in conjunction with the automatic vacuum brake on the train.

Two No. 8 injectors (Dewrance's) are fixed one on each side of the engine.

The tanks are made of best Staffordshire iron with ¼ in. rivets at about 1½ in. pitch. They have a water capacity of 800 gallons.

The coal bunker has a capacity of 80 cub. ft., being equivalent to nearly 2 tons of coal.

Fifty of these engines have been constructed at the Company's Nine Elms Works, and are now running, giving great satisfaction and being remarkably free from defects in working.

The following are the principal dimensions of the engine:

	Ft.	Ins.
Cylinders:		
Diameter	1	5½
Stroke	2	
Length of ports	1	2
Width of steam ports		1⅜
" " exhaust ports		3½
Center to center of cylinders	2	4
" " " " valve spindles		3¾
" line of cylinder to valve face		11⅜
Diameter of piston-rods		3¼
Motion:		
Lap of valves		⅞
Lead of valves		⅛
Maximum travel of valves		3¾
Throw of eccentrics		5¾
Diameter of eccentric-sheaves	1	3½
Length of cross-head slide block	1	1¾
Wheels (Cast Steel):		
Leading and driving wheels, diameter on tread	4	10
Bogie wheels, diameter on tread	3	
Thickness of tires		3
Width of tires		5½
Diameter of crank-pins for coupling-rods		3¾
Length of bearing-pins " "		4⅛
Diameter of cranks		7
Length " "		4
Axles (Steel). Bogie:		
Diameter of wheel-seat		7
Length " "		5⅞
Diameter of journals		5½
Length " "		10
Diameter at center		5¾
Centers of journals	3	7
Axles (Steel). Leading and Driving:		
Diameter of wheel-seat		8½
Length " "		6¾
Diameter of journals		7
Length " "		7⅛
Diameter at center (leading)		6¾
" " " (driving)		7
Centers of journals	3	11½
Frames (Steel):		
From front end to center of leading axle	5	6
From center of leading axle to center of driving axle	6	10
" " " driving-axle to center of bogie	11	
" " " bogie to back end	4	3
Total length of frames	27	7
Thickness " "		1
Total length of engine over buffers	30	8½
Width over platform	8	3
Boiler (Steel):		
Height of center from rail	6	10½
Length of barrel	9	5
" between tube-plates	9	9
" over all	14	5
Diameter of barrel (outside)	4	2
Thickness of plates		½
" " smoke-box tube-plates		¾
Firebox Casing (Steel):		
Length outside	5	
Width outside at bottom	3	10½
Depth below center line of boiler	4	9
Thickness of crown and side plates		⅜
" " throat plate		⅜
" " back "		⅜
Centers of stays (copper)		3⅜
Diameter of stays (copper)		1
Pitch of rivets		1⅜
Diameter of rivets		¾
Firebox (Copper):		
Length at bottom (inside)	4	3⅞
" " top "	4	2⅝
Width at bottom "	3	2⅛
" " top "	3	5½
Depth (inside)	5	5
Center of boiler to top of box (inside)		8
Thickness of crown and side plates		½
" " tube-plate at top		⅜
" " " " bottom		½
" " back plate		½
Tubes (Steel):		
Number		201
Diameter outside		1¾
Height:		
Top of chimney to rail	13	2¾

Tanks:

Contents of two tanks	800 gals.

Heating Surface:

Tubes	897.76 sq. ft.
Firebox	89.75 "
Total	987.51 sq. ft.
Grate area	13.83 sq. ft.
Flue area (201 tubes)	2.24 "
Chimney area	1.23 "
Cylinder area	1.67 "
Ratio of sectional area of chimney to grate area	1 : 11.27
" " grate surface to heating surface	1 : 71.4
" " flue area through tubes to grate area	1 : 6.17
" " cylinder area to grate area	1 : 8.28

Weight of Engine empty:	Tons.	Cwts.	Qrs.
Leading	12	8	2
Driving	13	8	2
Bogie	11	13	0
Total	37	10	0

Weight of Engine in Working Order:	Tons.	Cwts.	Qrs.
Leading	14	10	2
Driving	15	0	0
Bogie	15	1	0
Total	44	11	2

Weight of Engine:

Per foot run ..... 1.45 tons.

IRON AND STEEL WIRE.*

By Joseph Phillips Bedson.

That wire was known to the ancients there can be no doubt, for we read in Exodus 39 : 3, "And they did beat the gold into thin plates, and cut it into wires, to work it in the blue, and in the purple, and in the scarlet, and in the fine linen, with cunning work," in making the sacerdotal dress of Aaron, the High Priest of Israel; while wire, probably of similar style, it is recorded, has been discovered dating as far back as 1700 B.C. In the Kensington Museum there is a specimen of wire made by the Ninevites some 800 years B.C.; but all this wire was not produced as at the present time, the practice being to beat the metal into finely-hammered sheets, and then cut it up into fine strips or threads, and, as far as I can gather, this must have been the mode until toward the end of the fourteenth century. In the "History of Augsburg," dated 1351, and in that of Nuremberg, 1360, the metal-workers who made wire by means of the hammer are called "wiresmiths;" but in these works the term "wire-drawer" (*drahtzieher*) also occurs, from which one would infer that the draw-plate had been invented, but had not entirely superseded the ancient method. From these histories one is inclined to the belief that it was in Germany that wire-drawing was first carried on, after which it extended to France; for we find that at the end of the fifteenth century the invention of wire-drawing is ascribed to one Richard Archal, and iron wire in that country is called "fil d'Archal" and also "fil de Richard."

It is stated that wire was manufactured by hand in England until the year 1565, when a Saxon, Christopher Shultz, in company with some other foreigners, came to this country, under the permission granted by Queen Elizabeth to strangers, to dig for metallic ores, and introduced the drawing-plate. Previous to this the supply of iron wire, together with the combs employed by the wool-combers, was chiefly obtained from abroad. In the reign of Charles I. the wire-drawers of this country suffered as much by the competition of our German neighbors as we do to-day, for in a proclamation of this period it is stated that "iron wire is a manufacture long practised in this realm, whereby many thousands of our subjects have long been employed; and that English wire is made of the toughest and best Osmond iron, a native commodity of this kingdom, and is much better than what comes from foreign parts, especially for making wool-cards, without which no good cloth can be made. And whereas complaints have been made by the wire-drawers of this kingdom, that by reason of the great quantities of foreign iron wire lately imported, our said subjects cannot be set on work; therefore we prohibit the importation of foreign iron wire and wool cards made thereof, as also hooks and eyes, and other manufactures made of foreign wire. Neither shall any translate and trim up any old wool-cards, nor sell the same at home or abroad." From this it will be seen that the industry was of some importance even in Charles's time, and I doubt not but what there are some wire-drawers to-day who secretly would like some friendly power to prohibit the importation of foreign rods and wire into this country.

The Forest of Dean, which supplied good charcoal iron, was long the seat of the wire-drawing trade, where the metal was made in rods about ¼ in. square, about 3 lbs. to 4 lbs. in weight, from which the wire was drawn down into a circular form the required size. The two small samples herewith are actually pieces of charcoal iron rod strips which were manufactured at the Tintern Abbey works for wire-drawing purposes. I believe these works were originally started about 1575 by four families who came from Germany, and they first hammered (called "tilting") the charcoal iron into these ¼ in. square rods, which afterward they drew through draw-plates, but not on to blocks. This was effected by means of a long pole, which had a reciprocating motion, actuated by a water-wheel, and in this way worked backward and forward. In the forward stroke it drew the rod and wire through the plate, and on its return stroke, both of which were very slow, the workman sat and coiled up the length drawn by hand into a ring, and thus continued until the whole piece was drawn. The annealing was done in a kiln or brick oven, where the wire was heated to redness and allowed to cool naturally. This formed a lot of scale, which had to be removed by hammering, and then scoured in a barrel filled with wire and gravel and caused to rotate by water power, half immersed in water, for about 12 hours, when the wire was taken out, coated with flour lees, and ready for drawing on. The output of these works was about 26 cwt. per week.

According to Mr. J. Bucknall Smith, in his book on "Wire, its Manufacture and Uses," the first mechanical wire-mill proper in England was erected in 1663 at Sheen, near Richmond, Surrey, and from this date the industry maintained a substantial footing, and established a series of progressive developments, from which I should gather that the revolving block must have been in use.

In the seventeenth century the wire trade seems to have followed the woolen cloth manufacture into Yorkshire, and there, in the Halifax and Brughouse District, the largest quantity of card wire is manufactured to-day.

In the eighteenth century Birmingham began to figure prominently in the wire trade, a large quantity of wire being manufactured there; but at the beginning of this century Warrington began to take the lead as a large producer, and at the same time Manchester, with only one firm, kept well to the front in improvements, and, in fact, took the lead in iron telegraph wire of high quality.

So little had the wire trade progressed during the eighteenth century to the beginning of this, I well remember my father describing to me how his father, who was a Birmingham man and highly skilled in the drawing of steel for music and needle wire, drew a piece of bar steel 1 in. in diameter, 9 in. long, down to a wire as fine as the human hair, to exhibit before George IV. on his visit to Birmingham to see specimens and samples of the various trades carried on in that town, the mode being almost identical with the earliest practice. The bar was forged down to ¼ in. round, and then drawn through a draw-plate and annealed, as the nature of the material required, until it had assumed the finest possible size. I should add here that on the wire trade being taken up at Warrington an improvement was made over the mode as carried out in Birmingham. In the latter place the wire-drawer did all the work pertaining to his business—*i.e.*, he cleaned his rods, drew his wire, annealed it, and cleaned it again and drew it as required, and made it up ready to go out to the consumer. While it was a good school to learn in, it naturally followed that the wire was not as carefully handled to present a nice appearance to the eye. In Warrington this system was discarded, and the work subdivided between cleaners, annealers, drawers, and warehousemen, and I think it is to the credit of Mr. William Longshaw, of Warrington, who had the management of one of the oldest houses in the wire trade in that town, to have been the first to see the importance of this, and to put it into actual practice. Indeed, so much was it appreciated, that the wire not only was well received, but as a "market wire" secured a better price in the early days. Of course others soon followed in the same track.

I will now describe the *modus operandi* of wire-drawing, which is as follows: Ordinarily a wire rod, either No. 5 or No. 6, .212 in. and .192 in. respectively, is taken from the rolling-mill and placed in a cistern of hydrochloric or dilute sulphuric acid, and is allowed to rest there until the coat of oxide, which has formed in the hot rolling, is completely removed. It is then taken out and well washed with clean

* Paper read before the Iron and Steel Institute.

water to remove all trace of acid and dirt, and then coated with a mixture of lime and water, which is allowed to dry on. After this, the cleaning operation, the end of the rod is pointed, usually by mechanical means, and is handed to the wire-drawer for drawing to the size required. Previous to pointing the rod mechanically it was done by smiths or pointers in a smith's fire. The coil of rod was opened and the end heated in a fire under blast, and then, when heated sufficiently, the point was made on an anvil by the smith with his hammer. This, as can be readily seen, was feasible as long as the coils were only 20 lbs. or 30 lbs. each, but when they got to 150 lbs. and even 2½ cwt., it would be more difficult. The pointing machine, a modification of an American needle-pointing machine, does this very easily, and, whereas by hand the cost was about 1*s.* 10*d.* (44 cents) per ton, this machine does it for under 2*d.* (4 cents). The machine consists of a pair of rotating hammers running at 120 revolutions per minute, and capable of giving three times that number of blows in the same time, in doing which it forms the point described. The drawer is provided with a block which revolves at will on a vertical spindle, driven by a horizontal shaft through a pair of bevel wheels under the bench or table upon which the drawer works. On this bench-top is a tool-holder which holds the draw-plate, which plate contains many conically shaped holes of suitable sizes, and at their small end smaller than the rod which is to be drawn. These holes are roughly "pricked" in the plate by an experienced smith, and then the wire-drawer finally prepares and shapes the holes and their exact size, when cold, by taper punches. In this is the art of the wire-drawer coupled with the grinding of his punches suitably and always round and cylindrical. The size desired being decided upon, the drawer passes the aforementioned taper point of the rod through the plate, seizes the same with a pair of stout tongs, which are operated as required by power, and pulls a sufficient length through the draw-plate to enable him to secure this end to the vice which is mounted at the top of the block. This accomplished, the block is set in motion, and the whole of the piece is eventually wound on to the block, the wire-drawer taking great care that as the rod passes through the plate plenty of tallow or other lubricant is applied to the rod at the point of admission to the conical hole of the plate, otherwise the piece would "scrap" and eventually "pull the hole out," and thus deform it from its original size. As the wire is reduced in size by continual drawing, the material becomes more dense and hard, so that as the work proceeds annealing has to be resorted to to render the material suitably ductile once more. This is effected by placing the coils of wire in vertical cylinders, which, when filled with such wire, are hermetically sealed and heated to redness, and then allowed to cool slowly, and then the same operation of cleaning for drawing is gone through as before described. This obtains in all wire-drawing except as regards the draw-plates in very fine wire, in which jeweled dies, such as diamonds, rubies, etc., are substituted for the metal plate.

The first departure in wire-drawing, the date of which I am unable to say, was the adoption of the wince or block which revolved vertically on a spindle operated by hand. The next step was the application of power to this, water being the prime mover.

Iron wire was first drawn from square strips cut out of plates, until Cort's invention enabled round rods to be rolled, and even then these could only be produced of 12 lbs. to 14 lbs. each.

On June 12, 1837, Cooke and Wheatstone's first patent for an electric telegraph was sealed, and the adoption of this invention eventually created a great demand for wire, which began to make itself felt in the later years of the forties. Quickly following the national benefit of telegraphing naturally came the international desire, which resulted in the laying of the submarine cable between Dover and Calais in 1851. Two points of wire-drawing interest are attached to the drawing of the iron wire for this cable, the one being the long lengths of wire rods used—namely, No. 2 full rods of 30 lbs. each, and the second, I believe, being the first time rods were drawn through two holes without any intermediate annealing. In connection with the first point the wire drawers formed a deputation to ask for an advanced price for drawing these "long" pieces, and were almost successful in their application, had not Mr. George Bedson, who had the management of the works, and whose practical knowledge showed him how ridiculous the demand was, stepped in and demonstrated the absurdity of the request. It was also on the second point that Mr. Bedson's knowledge of the material to be dealt with caused this important departure to be made. With further reference to the first point, again, in 1865 or thereabouts, did the wire-drawers raise the question of extra price for drawing long rods when Mr. Bedson was rolling pieces of 112 lbs., and, indeed, they afterward went further and declared that to them was due the success of the continuous rolling mill, as they were able to draw the extra long pieces.

The first cable between Dover and Calais and several others connecting this island with our sister isle and also the continent proving equally successful, a desire to span the Atlantic was speedily gratified, for in 1858 the first cable was laid, and to quote Mr. W. H. Preece, F.R.S., etc., Chief Electrician to the Post Office Telegraphs and President of the Institution of Electrical Engineers, in his inaugural address to that Institution: "The first attempt was made in August, 1857, by H.M.S. *Agamemnon* and the United States frigate *Niagara*; but after paying out about 380 miles from the Valentia end the cable broke, and the expedition was abandoned until 1858, when the same two ships, this time commencing in mid-Atlantic and steaming in opposite directions, succeeded in laying the cable; but after 732 messages had been sent through, it again failed in October, 1858. Several unsuccessful attempts were made to pick it up, and the Atlantic scheme remained in abeyance until 1865, when a heavier cable was successfully laid, being the commencement of the present Anglo-American Company's system with its four cables now working across the Atlantic. There are now 11 cables bridging the Atlantic Ocean, 10 of which are duplexed.

Mr. George Bedson, seeing the importance of the telegraph-wire trade, tried to induce the people he was with at Warrington to launch out into this particular line; but failing in this, he took charge of a small wire-mill in Manchester, and it was here it fell to his lot to undertake the drawing of the iron wire for the Dover and Calais submarine cable, as well as the production of half the wire for the first Atlantic cable. The size of wire required for the Atlantic cable was exceedingly small, not at all on the same lines as the present cables, so that the drawing of this wire not only taxed the Manchester firm to its utmost, but several of the Yorkshire wire-drawers had to finish large quantities, which was done under Mr. Bedson's supervision. I do not think I can do better than give his own description of this wire as written by himself at the time, and which I accidentally found just recently among his papers. It is as follows:

"Description of the manufacture of No. 22 best charcoal iron wire (commencing with pig iron, and through the different stages as they occur, and apply to the wire supplied for the Atlantic submarine telegraph cable). A fine quality of pig iron having been selected, it is refined, and while in a fluid state is run into a plate of about 2½ in. thick. It is then broken up and worked in a charcoal fire into lumps of about 1¼ cwt. each. These lumps are shingled or hammered into blooms of about 4 in. square. The blooms are then heated, and after passing through a set of rolls, say, eight or nine times, they are reduced into bars of about 12 ft. to 14 ft. long and 1¼ in. thick. These bars are then cut into lengths of about 2 ft. each, and are called billets. These billets are then heated and passed through a train of rolls about 12 times, reducing them to No. 4 wire gauge, or a little less than ¼ in. in diameter. As these rods come from the rolls the last time through they are wound into coils 2 ft. 4 in. to 2 ft. 6 in. in diameter, and are now ready for the wire-drawer. These rods are pointed and then cleaned in dilute sulphuric acid, and when dried are drawn to No. 7 wire gauge, which represents $\frac{3}{16}$ in. in diameter. No. 7 wire is then annealed, and after being again cleaned is passed through the draw-plates twice, thus reducing it to No. 11 or $\frac{1}{8}$ in. in diameter. The annealing and cleaning process is again employed, and the wire passed twice through the draw-plates and reduced to No. 14, or $\frac{1}{13}$ in. in diameter. The annealing and cleaning process is here again used for the last time; the wire being now passed through the draw-plates seven times, is finally reduced to No. 22, or rather less than $\frac{1}{32}$ in. in diameter, it being 61 times its original length when in No. 4 rods. The quantity of wire required for this order was 950 tons, and it took 1,200 tons of wire rods to produce this quantity of finished material." The celebration of laying up this quantity of wire into cable took place on June 10, 1857.

Wire for telegraph and some fencing purposes has to be galvanized, as it is technically termed, but, more accurately speaking, coated with a thin film of zinc. This was effected up to 1860 in the following manner: The wire, after being drawn to the required size, is annealed in the annealing pot and afterward cleaned, both operations being done as before described; but instead of being dried, it is taken to the swifts or reels, upon which it is placed to be unwound in a wet state. The wire is then unwound and passed, first, through a shallow bath of dilute hydrochloric acid, to finally clean and prepare the surface of the wire to readily take the zinc, and thence through a bath of molten zinc, through which it passes and emerges at the opposite end through a bed of sand, which

regulates the quantity of zinc taken up, about .0015 of an inch a side for an average size of, say, No. 8, and thence to the blocks upon which the galvanized wire is finally wound. Wire treated in this manner often gave trouble, as it would sometimes become rotten through weak acid being present in the wet coils as they lay on the swifts before winding off, and then, again, the wire missed taking up the molten metal, as the surface had got dry and a thin film of oxide had formed, and many other sources of trouble, all of which tended to spread the opinion that all galvanized wire was exceedingly brittle and rotten, owing to the process it went through. In order, therefore, to meet these difficulties, Mr. Bedson invented, in 1860, his continuous galvanizing process, by which these difficulties were all overcome, and from which most excellent results were obtained. The *modus operandi* was as follows: The wire after having been drawn was taken direct in its bright state to the swifts, thence run off through a long furnace in which the wire was annealed, or even tempered if necessary; thence through a bath of hydrochloric acid, which cleaned the wire and threw down the oxide formed in annealing, and thence through the bath of molten zinc to the blocks; and this process has been the one gradually adopted, both in Europe and the United States of America, with success. During the life of the patent several firms were licensed to use the process, while some of our Continental competitors adopted it without grant of license, or even saying "by your leave."

About this time Mr. Bedson was induced to take the management of the Bradford Iron Works, Manchester, which the people with whom he was had acquired. At these works there were about 20 puddling furnaces, two metal helves, forge trains, and two wire-rod mills, and it was here that his attention was drawn to the shortness of the rods rolled, and the necessity of remedying the evil, if he were able, in order to produce such increased individual weights as had never been attempted before. The advantage of longer pieces was thus very forcibly pressed upon him, for the jointing and welding for telegraph lines was not only unsatisfactory, but dangerous. At last, in 1862, he patented his continuous rod-rolling mill, by which the billet, about $1\frac{1}{16}$ in. square and of 100 lbs. weight, was drawn from a Siemens gas furnace placed immediately in front of the first roll of the mill, and from this passed on through each successive pair of rolls, 16 in number, placed in line, and each running at an accelerated speed, according to the draft of each roll. This mill was very difficult to perfect, but by degrees it became a most perfect machine, and its capacity grew up to 20 tons of No. 5 iron wire rods in a turn of 10 hours.

I think I cannot do better here than quote from a report by Mr. Abram S. Hewitt, United States Commissioner to the Universal Exposition at Paris, 1867, on "The Production of Iron and Steel in its Economic and Social Relations:"

"The most remarkable specimen of rolling was in the English department in the shape of a coil of No. 3 wire rods weighing 281 lbs., in length 350 yds., rolled from a single billet. Also a coil of No. 8 wire weighing 200 lbs., 900 yds. in length, and a coil of No. 11 wire weighing 95 lbs., in length 790 yds. These wonderful specimens of wire were not, however, produced in an ordinary mill, but were rolled in a machine invented by Mr. George Bedson, the Manager of the Bradford Iron Works in Manchester. This machine consists of rolls in 13 pairs,* placed one behind the other, instead of side by side, as usual, with guides connecting the successive pairs of rolls, and revolving at such relative rates of speed that the billet being rolled receives the compressing action of the rolls at the same time. The billet is fed from a long feeding furnace at one end of the train of rolls, being charged at the end of the furnace furthest from the train. A Siemens generator is used to supply the furnace with gas, so as to insure a uniform heat. The average product of the train is 11 tons per day, and the weight of the billets usually rolled is from 80 lbs. to 100 lbs. A comparison of the work for six months with two old-fashioned trains also running in the same works shows that the waste is reduced from $10\frac{1}{4}$ per cent. to $6\frac{9}{10}$ per cent., and that the consumption of coal is reduced from 14 cwt., 3 qr., 25 lbs. to 8 cwt., 18 lbs. per ton, most of which saving is doubtless due to the use of the Siemens furnace and not to the train, the advantages of the latter consisting in an increase of product of nearly one-half, in the increased weight of the billets rolled, and in the economy of the labor employed. A personal visit was made to the Bradford Iron Works to see the operation of this ingenious and successful machine. It appears to be all that could be desired, and the action of the rolls upon the iron unquestionably produces a sounder and better rod than when worked by the old process, and this is due doubtless to the higher and more uniform heat at which the rod is finished.

"In the use of wire for telegraphic purposes, for wire suspension bridges, and for cables and ropes, the superior value of long lengths is undeniable. Bedson's machine has, therefore, the double merit of producing a better article at a lower cost than has hitherto been obtained; and it is a matter of regret to those who have become familiar with its novelty, and its merits, that it received only the recognition of a silver medal, when it so justly deserved the highest prize."

On this mill Mr. Bedson successfully rolled in iron No. 8 rods which were drawn in one hole to No. 9, in which size there was at one time a great demand for telegraph wire. Three of these mills were erected at the Bradford Iron Works, and there have run very successfully, on which rods can be rolled up to almost any weight; in fact, an iron wire rod has been rolled up to 1 ton weight. The only drawback to this mill was that it would not roll a common iron wire rod, and therefore its production was kept on telegraph wire and the best qualities of fencing wire, which had to pass a high specification. All the iron for it was, therefore, boxed-piled, having four square puddled billets in the center and four flats outside of either a best best puddled iron, or top and bottom of charcoal with sides of best best puddled iron, or charcoal all around. These were then known in the telegraphic wire trades as B. B., E. B. B., or four-sided charcoal, and out of one or other of these three grades the greatest telegraphic enterprises were constructed all over the world, and readily claimed for themselves a pre-eminence, owing to their great lengths of single pieces and their uniformity of quality. This continuous rolling-mill spurred on other rod makers in the direction of long lengths, but I believe throughout this mill stood at the head as the mill for a high-class quality of iron wire in longer lengths than was possible on any other system. It was with the aid of these inventions that Mr. Bedson, with his ability, skill, and inventive genius, raised the undertaking of which he had the general management from the smallest to the greatest eminence as telegraph-wire manufacturers, and it was particularly gratifying to him when Mr. Preece, in his paper on "Electrical Conductors," read before the Institution of Civil Engineers, on December 23, 1883, in referring to what Mr. Bedson had done, said: "I would mention how much telegraph engineers are indebted for the modern improvements in telegraph wire to the various inventions of this gentleman."

I should like to point out here that, in a paper recently read before the Institution of Civil Engineers by Mr. John Rigby, M.A., Superintendent of the Royal Small Arms Factory, Enfield, the continuous rolling-mill now in use at Enfield for rolling gun barrels at one heat out of a bar $1\frac{1}{4}$ in. in diameter, 1 ft. $3\frac{1}{4}$ in. long, therein described, was an almost exact copy of the first continuous wire rod-rolling mill, and I well remember some of the officials from Enfield coming over to Manchester to see this rod-mill in operation before they had constructed the one for Enfield.

About the year 1870 a change in the iron wire trade began to manifest itself, and that was the introduction of Bessemer metal. Although at first its regularity of carbon was not all that could be desired, and there were many failures, it gradually replaced iron where simply mechanical results were alone required. The introduction of this metal then enabled the wire rod-rollers to improve their plants, and thereby increase their lengths of rods, for the metal, being thoroughly homogeneous and capable of rolling at a lower heat, the difficulties which obtained in the rolling of iron no longer existed, and thus, where they were handicapped in iron, they were free in the rolling of steel, their success being due entirely to the character of the metal. The outcome of this was a considerable improvement in wire-rod mills.

At the period immediately preceding the invention of the continuous rod-rolling mill, a rod-rolling train consisted of a line of rolls three high, excepting the last or finishing pair, and men were placed on either side of the rolls to catch and stick in the rod as required, from the bolting-down rolls at the thick end to the finishing pair at the other. In the smaller sections, where the length had increased, loops were formed, and this involved the employment of lads to "hook" and keep these loops from getting entangled, which otherwise they readily would do. It was from this mill that many modifications and improvements were perfected to enable longer lengths and larger quantities to be rolled, and when to the mill a separate roughing mill was attached, driven at a low speed, and the older one at a higher speed, making what is commonly known in the rod trade as a "Belgian mill," we have the model of the generally adopted mill in this country. Many improvements as to economy in the use of labor have been introduced, notably repeaters, which guide the rod on the back of the rolls to the next pair automatically, thus sav-

* At Mr. Hewitt's visit, the mill was rolling larger sections, and therefore required a less number of rolls, hence 13.

ing a catcher and sticker in. An exception to this general adoption of the Belgian mill is found in Mr. John Bleckly's, of Warrington, who in 1872 patented improvements in wire rod-mills. For the description of this I am again indebted to Mr. J. Bucknall Smith's before-mentioned work. "According to this arrangement the rolls are superimposed so that a bar or rod passed through the first or top set is turned backward by the curved passage, so as to be automatically fed into the lower set. The working parts are suitably carried by the framing, while the proper relative position of the rolls may be adjusted by screw devices. A 'rod train' would be composed of a series of such rolls driven at increasing speeds through the intervention of suitable spur-gearing, in order to promptly take up the slack caused by the continually increasing lengths of the rods as they are diminished in thickness," and, according to my authority above mentioned, it "is capable of rolling from 370 to 400 tons of No. 5 gauge rods per week."

As an interesting example of the increase of production in rod-mills, the following will demonstrate the fact better than anything I can think of. In the old mills a boy at the reel could wind up easily all the rods rolled, the reel being on the same shaft as the cranked handle. In the first continuous rod-mill the quantity turned out increased, and so the reel had to be made with the handle to give one revolution to two of the reel, requiring at the same time increased power, so that a man had to be employed in lieu of the boy, and the product of the mill so increased that eventually, in 1870, the man had to be replaced with a pair of small engines running direct on the reel shaft, and worked by a boy at any required speed to take up the rod as quickly as it is rolled. In some places belts are used, but, as will be further explained, automatic reels are universally adopted in all the modern mills in the United States of America.

The use of Bessemer gradually grew to very large proportions up to 1884, when it received a very rude check, from which it has never recovered, by the introduction of basic Bessemer of Thomas and Gilchrist's patents. If there ever were a new system which revolutionized a trade, it was the introduction of basic metal for the wire trade, and further, if there ever were an old adage which had the lie given to it, it was the one that "you could not make a silk purse out of a sow's ear." To make myself more clear in my meaning, in our puddled iron days we could take any of the common ores which were made into pigs for puddling for wire purposes, and nothing but the poorest results were obtainable; nay, further, the wire rods would hardly stand drawing. Even go further and take the highest cold blast metal suitable for puddling made in this country, and the results were poor in comparison to what can be obtained from basic metal, and at fully half the cost. But now in basic metal these very same ores give the finest drawing material which was ever known, and can only be approached by the highest class of charcoal Bessemer metal as made in Sweden. To the inventors of this metal the wire-drawers of the world—*i.e.*, this country and Europe, as the United States are only users of the acid Bessemer, to any great extent for their wire trade are greatly indebted. I will not say how much, lest the makers should put up the prices; but, to put it in another light, I should not like to go back to a wire-mill drawing puddled iron wire rods. In fact, I question very much whether 25 per cent. of the workmen would be able to obtain a living thereby, at least not until they had discovered the peculiarity of this tender material.

In wire-drawing very few improvements have been made to the wire block. Mr. Bedson, early in the fifties, was the first to introduce the long pulling-in motion at one "ratch;" the old-fashioned plan being to pull in by the aid of a cam and lever attached to the pulling-in tongs at short "ratches," and as at each "ratch" the tongs had to take a fresh hold on the wire, they marked it and caused it to be cut off, thus involving waste, and this over short pieces of 15 lbs. to 20 lbs. was considerable. The long "pulling-in" had the great advantage of only taking hold of the wire once, and that at its end, which only involved a waste of 6 in., as against 24 in. to 30 in. in the older plan.

Mr. Edwin Woods, of Warrington, introduced, in 1872, a system of continuous drawing by a machine for drawing four holes at one operation, but it never achieved an extensive application or adoption.

For card-wire purposes improvements in drawing have been made in late years, for in the early part of 1886 I reported upon some labor-saving machines of the late S. H. Byrne's (of Brighouse, Yorkshire) invention, where 8, 10 and even 12 holes were being drawn at one operation. After experiments extending over a number of years Mr. Byrne took out his first patent in January, 1884, and from what I saw of the system I should think it highly successful. He was, I believe, the first in the field in this direction, and naturally he very soon had followers, by whom to-day large quantities of fine wire are drawn on this and similar systems.

Up to this point I have only touched upon the iron and steel wire trade, and although there are many other points that could be drawn in, I must leave them unnoticed, for, only being asked for a short paper, I am afraid of trespassing upon your good nature. However, I must briefly draw your attention to what may be termed the hard steel wire trade, where steel of carbons ranging from .7 upward is so manipulated that it will stand strains up to 120 tons per square inch, with torsional tests equally surprising. Such high-strained wire will not only stand 40 twists in 8 in. for No. 14 (.08 in. in diameter), but will allow of winding and unwinding upon its own diameter three or four times over, and this is the practice for the best patent steel for wire ropes for winding and haulage purposes.

I believe it is to Mr. Horsfall, of Birmingham, in 1854, that the credit of first attempting to harden and temper cast-steel wire is due; but it is to the late Mr. William Smith, of Warrington, that the secret of this "patent" wire process of to-day is due, and he worked for many years on these lines almost unapproached by any other makers in the land or even in the world; in fact, his firm practically had a monopoly. However, the secret leaked out, and is now possessed by various makers in this country, who are able to produce this very high-class wire.

As regards the Continent, Germany is the great wire-producing country, but beyond what has been done in this country in the way of improvements and developments in wire manufacture little can be said, except with regard to the rod-mill patented by Mr. Boecker, of Schalke, which consists of two trains of rolls placed parallel with each other, and speeded with such suitable gearing to take up the increased length of the rod as it passes from one set of rolls to the opposite parallel pair. This mill is doing excellent work at the present time, and is practically the only novelty in the wire trade in Germany that I know of.

As to the development of the manufacture of iron and steel wire in the United States of America and its early history, naturally more definite information is obtainable; and while in wire-drawing nothing new has been introduced, wire-rod rolling has been developed and perfected to a far greater extent than in any other country in the world. This has been very fully set forth by my friend, Mr. F. H. Daniels, of Worcester, Mass., in his paper on "Rod-Rolling Mills and their Development in America," read before the Mechanical Engineering Section of the World's Engineering Congress, Chicago, Ill., U. S. A., August, 1893.

Wire-drawing was introduced into the United States about 1666, and was one of the early industries taken up by the New World. Its use was very similar to that in this country, and it had to depend upon the slit rods very much in the same way as we had, and as previously described. This system of producing wire rods remained in vogue, without material advancement, until between 1830 and 1860. One of the first improvements, if not the first, was made at Fall River, where a rod-mill was built by the Fall River Iron Works Company. The original mill was erected in 1839, but was destroyed by fire and rebuilt in 1843. The output of the original mill was about 3 tons a turn of 1-in. rods weighing about 10 lbs. each. After the mill was rebuilt the billet was increased to 25 lbs., and rods were rolled as small as $\frac{3}{16}$ in. in diameter, giving 5 to 8 tons per turn, according to the size of the rod rolled. One of the best mills of this type running up to 1860 was erected by Ichabod and Charles Washburn, at Quinsigamond, Worcester, Mass., which could produce 9 tons of No. 4 rods of 20 lbs. to 30 lbs. pieces in one turn, and this was considered a very remarkable output.

Until 1860 looping mills were unknown, the billets being passed through the rolls back and forward, and this accounts for the light weight of billets used. The demand for longer lengths now stirred up wire-rod rollers, as the telegraph and suspension bridge engineers were calling for material with less welds and joints, and early in the sixties Mr. Ichabod Washburn (quoting from Mr. Daniels's paper), "during a visit to England made the acquaintance of Mr. George Bedson, of Manchester. Messrs. Washburn and Bedson afterward became warm friends, and an extensive correspondence and exchange of ideas regarding wire-making passed between them." It is with no ordinary feeling of pleasure and gratification to me, as the son of the late George Bedson, to hear of him being referred to at the World's Engineering Congress at Chicago, about nine years after his death, in such high terms by Mr. Daniels in the paper referred to, when he says that "Bedson was without doubt the best-informed and most skillful wire

and rod expert in Europe. Mr. Washburn was informed by Mr. Bedson from time to time regarding his experiments in the direction of rolling wire rods continuously, and he became very enthusiastic regarding the possibility in this direction. . . . Mr. Washburn decided that the Bedson mill would be of great advantage to his company, and accordingly in the fall of 1869 one of these continuous rod-wire rolling-mills was erected at the Grove Street Works, Worcester, Mass." Mr. Bedson, therefore, has the double credit of having reduced the idea of continuously rolling rods both in England and America to a successful issue. This mill was built in England and worked by English workmen, but in the hands of Mr. C. H. Morgan, and latterly of Mr. F. H. Daniels, both of Worcester, Mass., it has received enormous developments, and mills designed on the continuous system by both these gentlemen have been constructed to turn out as much as 2,000 to 2,500 tons of wire rods in a week.

As in England and Germany, the old-fashioned rod-mill was altered on to the Belgian type, as previously described, and out of this system my friend, Mr. William Garrett, designed and perfected his patent rod-mill. It consists of a roughing mill, which takes a 4-in. bloom, an intermediate mill, and a finishing train of rolls divided into two parts, the second half running at an accelerated speed to the first half. Out of this mill he has obtained wonderful results, and in the one he erected at Joliet he produced upward of 150 tons of No. 4 wire rods in 10 hours, and the rods weigh about 150 lbs. each. These large products have been made possible chiefly by the use of the automatic reel placed at the delivery end, and which winds up the rod immediately it is rolled, thus preventing all slack or accumulation, which would otherwise snarl and both spoil and stop progress.

These automatic reels were experimented upon in 1879, and on February 24, 1880, letters patent were granted to Mr. C. H. Morgan and Mr. F. H. Daniels, of Worcester, Mass., and I think to them is due the credit of working this new system out to a successful issue. All the large rod-rollers in America have their special reeling apparatus, but they are practically modifications of the principles enunciated at the outset by Messrs. Morgan and Daniels.

The rod-rolling capacity of the United States is estimated as follows:

	Gross Tons.
Garrett system, running at maximum capacity.....	650,000
Continuous system, running at maximum capacity...	250,000
Other forms of mills, running at maximum capacity.	100,000
	1,000,000

It will naturally be asked where all this material goes, and when I can account for almost one-half of its going in two articles, others will suggest themselves to fill up the balance. One of the two items is barb wire, and it was first made in the fall of 1873 at De Kalb, Ill., by Mr. J. F. Glidden. In 1874 the output was 5 tons, and now the present yearly production is 200,000 tons. The second item is wire nails, the use of which was scarcely known in the United States 10 years ago, and now reaches 200,000 tons, and they are driving cut nails out of the market.

As regards the uses of wire, I shall only shadow out a few of the principal and leading articles of the trade, such as fencing, telegraph, rope wire for hauling purposes, and for ships' rigging, and leave it to your own imaginations to fill up the thousand and one articles and uses to which it is daily applied for our wellbeing and comfort. It is used in our boots and shoes for rivets, and it is used in our hats for stiffening their brims; and in thus giving you the head and the feet, you can readily fill up the intervening space.

With reference to our production in this country, I find, according to the Board of Customs returns, that we exported in 1892 wire (excluding telegraph wire) 47,350 tons, as compared with 67,516 tons in 1891; and in estimating our total capacity, I should fancy that about 100,000 tons of wire rods of all grades can be rolled here annually; perhaps it may be capable of reaching as high as 120,000 tons.

THE EXHIBIT OF THE BETHLEHEM IRON COMPANY AT THE WORLD'S FAIR.*

By Lieutenant William H. Jacques.

If I can atone in any way for America's very inadequate representation of her steel productions by a recitation of what the Bethlehem Iron Company sent to the World's Columbian Exposition, I shall feel I have done a service to our profession. But I shall make no attempt to compare the Bethelehem exhibit with that of Mr. Krupp, which is a veritable exposition in itself, but shall present it only as showing the latest and highest development of the class of objects it covers.

On entering the Transportation Building, even those unacquainted with the products of iron works are attracted to the gigantic structure that strides the main aisle, like the Colossus of Rhodes. This is an exact reproduction of Bethlehem's 125-ton steam hammer—the largest in the world—under which the heaviest armor-plates are finished and shaped. It towers, 91 ft. in height, to the very roof beams, and so excellently have the wood and staff been molded together, that to all appearances the model is solid iron. The anvil-block could not be shown in place, as it would obstruct the passageway.

As a description of this hammer may be of interest, I present some details prepared for Mr. Swank for the last edition of his "Iron in All Ages." Although since the completion of the Parks Brothers' 17-ton hammer, two others of moderate proportions have been erected—viz., the 20 ton hammer of the Latrobe Steel Works and the Midvale hammer of 30 tons, both employing top steam to increase their forging power, it has been left for the Bethlehem Company to add to its already splendidly equipped plant the largest and most efficient hammer in the world—a single-acting instrument of 125 tons. The building in which this hammer has been erected is 500 ft. long, and is located on ground that was partly an island and partly the bed of the southern channel of the Lehigh River, turned from its course to provide the hammer site.

A pit 80 ft. square was excavated below the water level and piles were thickly driven, both for the anvil foundation and hammer frames. The stone walls for supporting the latter have a depth of 30 ft., separated from the anvil foundation lest any sinking of this latter should affect the framework of the structure itself.

The hammer rises to a height of 90 ft. from the floor-line. The housings proper are each composed of two parts, the lower ones weighing 71 tons each, the upper ones 48 tons each These are bolted together and surmounted by an entablature of 61 tons carrying a cylinder of 76 in. in diameter by 24 ft. high. The housings are clamped to base plates, each 10 ft. × 8 ft. and weighing 56 tons, giving a 42 ft. longitudinal width of frame and a working floor width inside of housing of 22 ft. A 16-in. steel piston-rod 40 ft. long actuates the enormous tup, which is composed of three parts, two forming the ram, a third the die. The hammer is single-acting, steam-lifting only, the total weight of falling parts, length of stroke and gravity governing the work done.

The anvil foundation consists of piles driven to bedrock or gravel, timber frames, cork and shavings cushion, steel slabs and 22 iron blocks carefully machined and fitted, forming a metal mass of 1,800 tons, arranged in the form of a pyramid. To secure an even floor for working, the spaces between the frame and anvil foundations are closed with cribbing, leaving exposed only the anvil block. The specially designed valve-gears have worked most satisfactorily, one man easily controlling the motions with one hand.

The hammer is served by four heating furnaces conveniently placed and by four gigantic cranes, each of 300 tons capacity, having longitudinal, transverse, vertical and turning motions, by which every position and movement of the forgings can be easily controlled.

In describing this hammer as one of 125 tons, it is meant that the weight of tup (including die), piston, and rod is 125 tons, which falling a distance of 16½ ft. (full stroke) without top steam produces the full power of the hammer.

The Principal Powerful Steam Hammers in the World are:

Company.	Town.	Country.	Type.	Weight in Tons.
Sir Wm G. Armstrong, Mitchell & Co., Ltd...	Elswick, N'-on-Tyne...	England.	Top-steam....	35
British Government....	Woolwich	England.	Top-steam....	35
Kama Steel Works.... ..	Perm.....	Russia ..	Single-acting.	50
Aboukoff Steel Works..	Aboukoff.....	Russia ..	Top-steam....	50
Cast Steel Works of Fried. Krupp.....	Essen...	Rhenish-Prussia..	Single-acting.	50
St. Chamond Steel W'ks	St. Chamond... .	France..	Single-acting.	80
Schneider & Co.....	Le Creusot	France..	Single-acting.	100
Marrel Brothers.....	Rive-de-Gier... .	France..	Single acting.	100
Terni Steel Works.... .	Terni	Italy.....	Single-acting.	109
The Bethlehem Iron Co.	S. Bethlehem, Pa.	U. S. ..	Single-acting.	125

In describing these hammers, the *weight* given is the sum of the moving parts—*i.e.*, piston, piston-rod, tup and die. The column headed *type* indicates whether top-steam is employed or not.

Begun in 1889, the Bethlehem hammer was successfully put in operation June 30, 1891, since which time many huge forg-

* Paper read before the Engineers' Club of Philadelphia.

ings for armor-plates and other war and structural material have been shaped under it.

The exhibit proper was divided into three sections. In the first were two immense steel forgings for the tube or barrel and jacket of a Navy 13-in. B. L. rifle, weighing respectively 26.3 tons and 25 4 tons—examples of hydraulic forged hollow steel forgings. Here was also the nickel-steel ventilator armor for the monitor *Puritan*, 7 ft. in diameter, 6 in. thick, weighing 9.1 tons, forged in one piece without welds. A feature of this section was a Navy 12-in. B.L. rifle, fabricated at the Washington Navy Yard of Bethlehem's fluid-compressed, hydraulic forged steel. It weighed 45.2 tons, was 37 ft. long, had a muzzle velocity of 2,000 foot-seconds, and fired an 850-lb. projectile with 425 lbs. of powder with an energy sufficient to perforate 22½ in. of iron. Its outside diameter was 3 ft. 9 in.

In the second section was a model of a 113-ton steel armor-plate ingot and a pile of forged steel hoops, with which were three splendid examples of steel armor. The largest was a curved 17-in. nick-steel plate, 12 ft. 1 in. long, and 8 ft. 4 in. wide, weighing 31.2 tons—one of 13 required to form a barbette of the battleship *Indiana*. The armor required for this battleship was:

Kind.	No. of Plates.	Thickness.	Weight, Tons.
Diagonal	10	14	245
Side	20	18	650
Barbettes for 13" B. L. R.	26	17	810
" " 8" B. L. R.	8	8	115
" L" 4" B. L. R.	4	6	43
		Total	1,863

The next was a case-hardened nickel steel plate, 10½ in. thick, 8 ft. long, 10 ft. wide, weighing 9.3 tons, which was subjected to an attack of the enormous energy of 25,040 foot-tons, during which the five 8-in., 250 lb. Holtzer armor-piercing shells lost their identity and were completely pulverized without seriously injuring the plate. The third plate was the first heavy steel armor-plate made in the United States. It was 11½ in. thick, 6 ft. long, 4 ft. 6 in. wide, and was tested in 1891. It weighed 5.7 tons. In this section was one of the most remarkable articles of the exhibit, a fluid-compressed steel ingot 15 ft. long, 54 in. in diameter, weighing 48.3 tons. From a similar ingot weighing 65 tons, the axle of the famous Ferris wheel was made. The third section contained a hollow hydraulic-forged shaft 67 ft. long and 20 in. in diameter, weighing 24.6 tons, with an internal diameter of 8½ in., forged in one piece; together with the paddle-shaft for the Old Colony Steamer *Puritan*, 39 ft. 5 in. long, 2 ft. 3 in. in diameter, having a 9-in. hole, and weighing 39.4 tons; and the crank-shaft for the United States cruiser *Minneapolis*, 9 ft. 7⅛ in. long, 16¼ in. in diameter, having a 7½-in. hole and weighing 4 tons. Both of these were finished.

Accompanying these were a smooth forged trunnion hoop for a 12-in. armor gun, Whitehead torpedo, air flasks, air cushions, cylinders, sections of rails, specimens of nickel steel, etc.

CONTRIBUTIONS TO PRACTICAL RAILROAD INFORMATION.

Chemistry Applied to Railroads.

SECOND SERIES.—CHEMICAL METHODS.

VII.—METHOD OF DETERMINING MANGANESE IN STEEL.

By C. B. Dudley, Chemist, and F. N. Pease, Assistant Chemist, of the Pennsylvania Railroad.

(Copyright, 1891, by C. B. Dudley and F. N. Pease.)

(*Continued from page* 129.)

OPERATION.

Put 3 grams of the fine borings in a 16-oz. Erlenmeyer flask, and add 50 c.c. of dilute nitric acid, specific gravity 1.13. Put on the steam table or over the lamp, and as soon as solution is complete, add 100 c.c. of concentrated C. P. nitric acid, specific gravity 1.42. Heat to boiling, withdraw from the fire momentarily, then add 5 grams of crushed chlorate of potash, free from manganese. Replace over the heat, and boil 10 minutes; then repeat the operation with 5 grams more of chlorate. Allow to cool, then filter through an asbestos filter, and wash both flask and filter with distilled water, until the washings no longer react acid. Put the asbestos with the manganese on it back into the flask, and add 50 or 100 c c. of ferrous sulphate solution, agitate until the manganese is all dissolved, then titrate the excess of ferrous sulphate with permanganate of potash.

APPARATUS AND REAGENTS.

The apparatus required by this method needs no especial comment, except, perhaps, the asbestos filter. The ordinary well-known funnel and platinum perforated cone may be used, but better the glass tube filter. Instead of using those made with constrictions, such as are usually shown in apparatus catalogues for filtering acid solutions, a tube drawn out at one end to go into the hole in the cork, and with a flat coil of platinum wire to hold the asbestos, is preferable. Those made from 1½-in. tubing, about 8 in. long when finished, and with the drawn-down portion about 3 in. long, work nicely. The flat platinum coil is about ⅜ in. in diameter, and has a tail of the same wire hanging down from the center of the coil, about 4 in. long, to assist in removing the filter from the tube after the washing is finished.

The C. P. nitric acid is obtained in the market, and the dilute is made from it by adding distilled water.

The chlorate of potash is the commercial salt obtained in the market.

The asbestos which works best is the mineral known as actinolite. Much of the asbestos of the market packs badly under suction and retards filtration.

The ferrous sulphate solution is made by adding 2 liters of concentrated C. P. sulphuric acid, specific gravity 1.84, to 14 liters of distilled water in which has been dissolved 80 grams of C. P. ferrous sulphate. It is not necessary to filter. After all the reagents are together the solution is thoroughly mixed, and its strength obtained in terms of the permanganate solution. Fifty c.c. of the ferrous sulphate solution require about 15 c.c. of permanganate. Not less than three tests should be made, and they should agree within a tenth of a c.c. If not the temperatures, the burette, the pipette, or the mixing of the solutions, one or all, are at fault.

The permanganate of potash solution for titration is made as follows: To 1 liter of water add 2 grams of crystallized permanganate of potash, and allow to stand in the dark not less than a week before using. Determine the value of this solution in terms of metallic iron. For this purpose 150 to 200 mg. of iron wire or mild steel are dissolved in dilute sulphuric acid (10 c.c. of strong C. P. acid to 40 c.c. of water) in a long-necked flask. After solution is complete, boil 5 to 10 minutes, then dilute to 150 c.c., pass the liquid through the reductor, and wash, making the volume up to 200 c.c. Now titrate with the permanganate solution. It is, of course, essential that the amount of iron in the wire or soft steel should be known. The standard in use in the Pennsylvania Railroad Laboratory is a mild steel, in which the iron is known by determining carbon, phosphorus, silicon, sulphur, manganese and copper, and deducting the sum of these from 100 per cent. Not less than two determinations are made, and three are better. The figures showing the value of the permanganate solution in terms of metallic iron should agree to a hundredth of a milligram in the different determinations. A very satisfactory method of making and keeping permanganate of potash solution is as follows: Have a large glass bottle holding, say, 8 liters and two of half the size. Paint the outside of these bottles with several coats of black paint or varnish. Fill the large bottle with the standard solution, and after it has stood a proper time, fill one of the smaller bottles from it without shaking and standardize. At the same time fill the second small bottle and refill the large one. When the first small bottle is exhausted, standardize the second one and fill the first from the stock. When this is exhausted standardize the first again and fill the second from stock, refilling again the stock bottle and so on. By this means a constant supply of sufficiently matured permanganate is always available. Of course if the consumption is very large, larger bottles or more of them may be required. Since changes of temperature affect the volume of all solutions, it is desirable that the permanganate solution should be used at the same temperature at which it was standardized. With the strength of solutions above recommended, if the permanganate is used at a temperature of 20° F. different from that at which it was standardized, the error amounts to less than 0.003 per cent. on a steel containing 0.50 per cent. of manganese.

CALCULATIONS.

Atomic weights used: Iron, 56; manganese, 55. Molecular formulæ used: Ferrous sulphate, $FeSO_4$; manganese dioxide, MnO_2; sulphuric acid, H_2SO_4; permanganate of potash, $K_2Mn_2O_7$; water, H_2O. Reaction in ferrous sulphate solution, $MnO_2 + 2\,FeSO_4 + 2\,H_2SO_4 = MnSO_4 + Fe_2(SO_4)_3 + 2\,H_2O$.

The soft steel employed in standardizing permanganate of potash solution in the Pennsylvania Railroad Laboratory contains 99.27 per cent. metallic iron; 0.1498 gram of this con-

tains therefore (0.1498 × 0.9927) .1487064 gram of metallic iron. This requires, say, 42.9 c.c. permanganate solution, or 1 c.c. of permanganate solution is equal to (.1487064 ÷ 42.9) .003466 metallic iron. Assuming now that the manganese oxide obtained is MnO_2, it is obvious that two molecules of $FeSO_4$ are required for reaction with one molecule of MnO_2, or the ratio between Fe and Mn in the reaction in the ferrous sulphate solution is as 112 to 55. But each c.c. of permanganate is equal to .003466 of metallic iron, and consequently (112 : 55 :: .003466 : .0018) each c.c. of permanganate is equal to .0018 gram of metallic manganese. Suppose now that 50 c.c. of the ferrous sulphate solution is equal to 14.9 c.c. of the permanganate solution, and that after the manganese oxide on the asbestos filter has been added to 50 c.c. of the ferrous sulphate solution, and the reaction between these is complete, it requires 4.1 c.c. of the permanganate solution to react with the excess of ferrous sulphate. It is evident that the amount of manganese in 3 grams of steel is equivalent to (14.9 — 4.1) 10.8 c.c. of the standard permanganate solution, that is to (10.8 × .0018) = .01944 gram of metallic manganese. Then if 3 grams or parts of steel contain .01944 gram of manganese, 1 gram or part would contain (.01944 ÷ 3) .00648 gram, and 100 grams or parts would contain (.00648 × 100) .648 gram or 0.648 per cent. This explanation may be briefly summarized as follows: Obtain the strength of the permanganate solution in terms of metallic iron. Then obtain the strength of the same solution in terms of metallic manganese in accordance with the reaction given above. Next find the equivalent of the amount of ferrous sulphate solution to be used in an analysis in terms of the permanganate solution. Then, after the number of c.c. of permanganate solution, equivalent to the manganese in the steel are obtained, multiply these by the manganese equivalent of the permanganate solution. Move the decimal point two places to the right, and divide by 3. The quotient will be the per cent. of manganese in the steel. It is, of course, evident that the manganese equivalent of the permanganate may be divided by 3, and the decimal point moved two places to the right before multiplication, which still further simplifies the calculation.

NOTES AND PRECAUTIONS.

This method, it will be observed, separates the manganese from the iron in nitric acid solution by means of chlorate of potash, catches the precipitated oxide of manganese on an asbestos filter, and determines the amount of the manganese by means of the reaction between ferrous sulphate and this oxide in sulphuric acid solution permanganate of potash being used, to measure the change in the ferrous sulphate solution, produced by the manganese oxide.

The use of dilute nitric acid to effect rapid solution of the steel, and the subsequent addition of the specified amount of concentrated acid, is found to give exactly the same results as are obtained when the steel is dissolved in concentrated acid from the start, or as are given when a larger quantity of dilute acid is used to start with, followed by subsequent concentration. The saving in time by the method recommended amounts to from one to two hours.

It sometimes happens that no precipitation of manganese oxide will follow the first addition of chlorate, and even sometimes the second addition is very slow in producing a precipitate. It is hardly safe to pronounce no manganese present until quite continued boiling, and further additions of chlorate, and even more nitric acid and further boiling leave the solution quite clear. After the precipitation is once started it apparently goes on to completion without difficulty. It is not advisable to add the chlorate of potash to the boiling solution over the fire. Under certain conditions disastrous explosions follow such practice.

It occasionally happens that permanganic acid is formed in the nitric acid solution. When this is the case, the filtrate will in some cases at least be clearly pink in color, and on standing oxide of manganese will separate. It is believed that this possible difficulty is obviated by allowing the nitric acid solution to cool before filtration. This practice is regarded as better than adding fresh unboiled concentrated nitric acid, as has been recommended, since fresh nitric acid may contain nitrous acid, in the presence of which the separated manganese is somewhat soluble.

The length of time that the nitric acid solution with the separated manganese oxide in it may stand without injury seems to be considerable. Duplicate determinations made on the same steel, in one case as rapidly as the manipulation could be carried through comfortably, and in the other case, allowing the precipitated oxide to stand in the nitric acid solution 12 hours before filtration, gave exactly the same results in both cases. Diluting the acid with water after the flask is removed from the fire and then allowing to stand is disastrous. A direct test showed that in 12 hours' standing under these conditions about half the manganese had dissolved. Of course during standing the flasks should not be exposed to direct sunlight for fear of formation of nitrous acid.

It does not seem to be necessary to wash the precipitate on the filter with either concentrated or dilute nitric acid, as was formerly directed. As soon as the liquid from the flask has all run through, water may be used at once for washing both flask, filter tube, and filter.

The necessity for the complete removal of every trace of nitric acid by the washing is very great. A very small amount of nitrous or nitric acid in the ferrous sulphate solution may so interfere with the permanganate titration that the results will be worthless. Large quantities of water may be safely used in the washing, and the last drops from the filter tube should be tested with phenolphthalin, or some other delicate indicator.

Whether it is advisable to use the pump or not during the filtration seems to be largely a question of the asbestos used. With certain kinds of asbestos a plug ¼ in. or more in thickness may be used in the filter tube, and the suction from the pump applied vigorously. With other kinds of asbestos this procedure results in packing the asbestos so tightly that filtration is retarded, and the subsequent solution of the manganese oxide in the ferrous sulphate solution is also seriously retarded. A mixture of poor asbestos with glass wool works nicely with the pump. Where one operator has six or eight determinations to filter at one time there is no advantage in the pump. With a properly made asbestos filter the liquid will run through as rapidly as it can be poured into the tubes.

The asbestos for filters can be used over and over again, and does not seem to deteriorate from use. After the titration is finished the flasks are emptied into a large beaker, the liquid drained off, and the asbestos washed three or four times by decantation, when it is ready for further use.

For steels containing 0.90 per cent. or over of manganese, it will be necessary to use more than 50 c.c. of the ferrous sulphate solution. In case the manganese oxide does not completely disappear after a little agitation when 50 c.c. of the ferrous sulphate solution has been added, leaving the asbestos perfectly white, add 50 c.c. more of the same solution and agitate again. Of course the calculations must be varied in accordance with this change.

Very few steels contain enough silicon to cause trouble in the filtration provided the pump is not used, and it is very rarely necessary to separate silicon before determining the manganese. When the amount of manganese is very large, the filtration is sometimes slow, but if care is taken to keep the tube full of liquid and not to pack the asbestos too tight, there is usually no serious difficulty.

There are some indications that the separated oxide of manganese may not be exactly MnO_2. Positive experiments on this point are wanting, but comparative experiments on the same steel by the method given above, and by the acetate-bromine method, show that for steels containing not more than 1 to possibly 1½ per cent. of manganese, the error, if any, can safely be ignored.

When everything works well a determination can be made by the method above described in from an hour to an hour and a half.

MEETING OF THE MEMBERS OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

RECENT IMPROVEMENTS IN THE EMERY TESTING MACHINE.

THE March meeting of the members of the American Society of Mechanical Engineers was held at the house of the Society in New York, on the evening of Wednesday the 14th, with Mr. Eckley B. Coxe in the chair. The paper of the evening was read by Mr. Sellers Bancroft, and related to the recent improvements that have been made in the Emery testing machines. Mr. Bancroft spoke as follows:

Mr. Chairman and Gentlemen:

I propose to describe to-night some of the recent improvements in the Emery testing machine, but in order that those improvements may be thoroughly understood, it is perhaps necessary to go over ground which is familiar to many of you, and for that purpose I have a view showing just the scheme of the machine.

The essential peculiarity of the Emery testing machine is the method by which the stress produced upon the piece tested is conveyed to the scale and accurately weighed by mechanism that is entirely frictionless, and that hence responds to the same

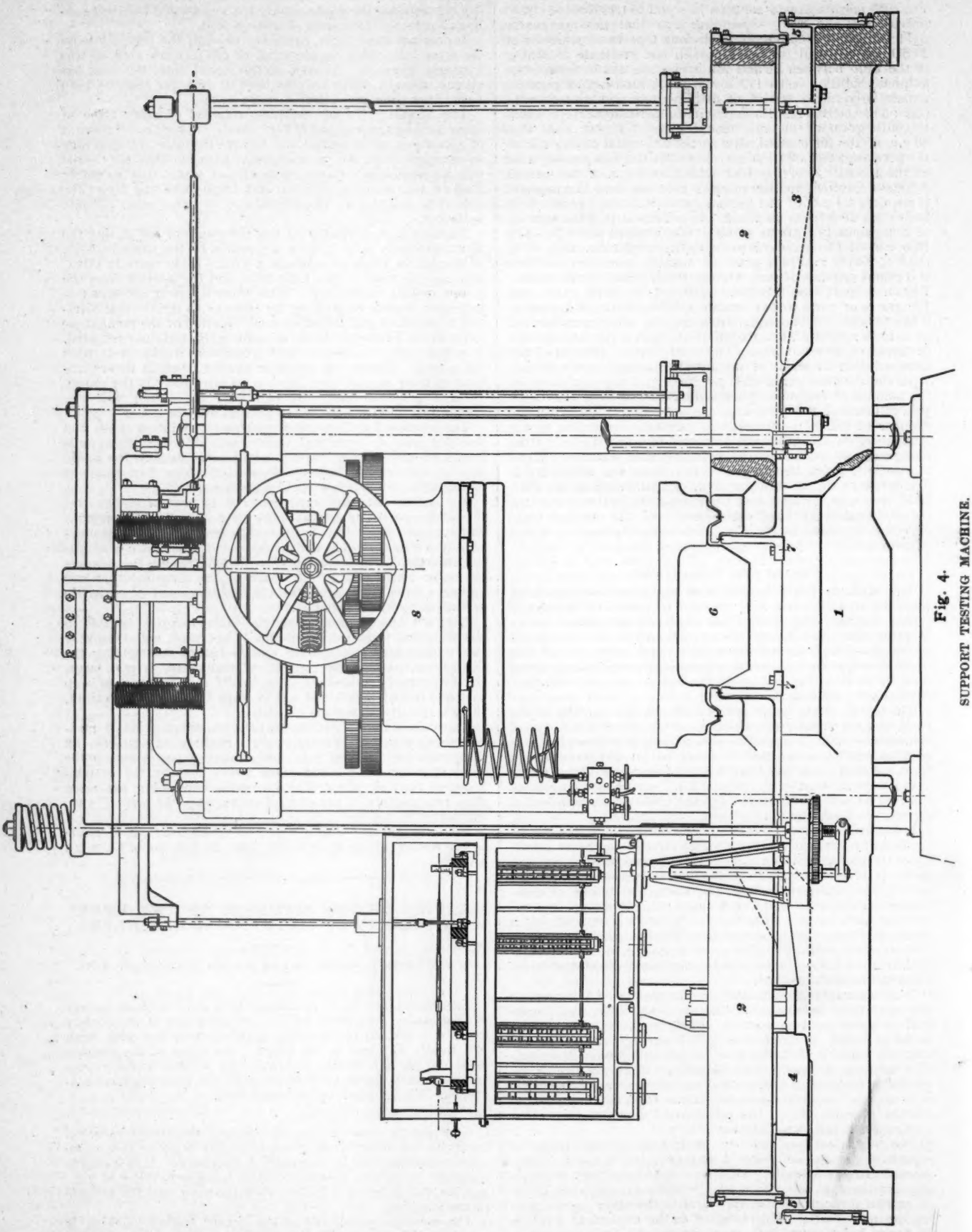


Fig. 4.
SUPPORT TESTING MACHINE.

increment of load regardless of the amount of strain upon the specimen.

This result is accomplished by receiving the load upon a hydraulic support or upon a group of them, as the case may be. The general scheme is indicated in fig. 1, which merely shows the relation of the parts, no attention being paid to proportion. The depth of the cylinder *a*, which merely represents the main hydraulic support, is exceedingly shallow, and the end is closed to prevent the escape of the contained fluid by a thin sheet of metal *b*, upon which rests a piston *c*, considerably smaller than the internal diameter of the cylinder, giving a free span of metal between the two. This piston is secured to the cylinder by a thin flexible fixing plate or plates *d*, *d*, which permit a very small movement in the direction of the axis of the cylinder, while rigidly securing it against any lateral movement. This longitudinal movement of the piston from no load to full load is not more than, say, .003 in., and as there is no hydraulic packing and no sliding, there is no friction beyond that of the fluid. This hydraulic chamber is filled with liquid and connected by a pipe, *e*, with a smaller but similar chamber *B*, the ratio between the two being from 20 to 1 to 30 to 1 on small scales to several hundred to one on large scales. This small chamber is placed in the scale, which may be at any reasonable distance; the piston *c'* of this latter chamber acts through the block *H* against the first lever *C* of the scale, which thus receives a fraction of the load upon the piston *c*, determined by the relation between the areas of the two hydraulic cylinders *A* and *B*.

The scale body is a rigid cast-iron frame indicated by the shade lines under the lever supports *G*, *G'*, *G''*, and over the reducing chamber *B*. All the supports and connections of these levers are thin flexible plates of steel firmly secured or clamped to the levers and their supports, and having a sufficient exposure between their fixed ends so proportioned to their thickness and the loads they have to carry that the amount of bending due to the movement of the levers shall be well within the elastic limit of the material. The long arm of the lever *C* is coupled by the bar *D* with the short arm of the poise frame lever *E*; the long arm of this lever carries all the standard weights of the scale, and the method of putting them on or taking them off is peculiar to the Emery system. Suspended from this lever *E* at suitable intervals by thin fulcrum plates are poise frames *N*, consisting of an upper cross-head *S* and a lower cross-head *T*, united by three vertical bars disposed at equal intervals about the cross-heads.

These bars are provided on their inner faces with short projecting brackets *V* having a horizontal surface and a beveled surface, which correspond with similar surfaces formed on the weights *h*, which are short cylinders or rings with beveled edges; the weights are carried by the flat surfaces and centered by the beveled surfaces. A weight frame *M* of the same construction has its three vertical bracketed bars alternating with the bars of the poise frame; this weight frame is guided and is raised and lowered in a vertical line without touching the poise frame by a rock-shaft and hand lever coupled to the rod projecting from the cross-head *R*. The brackets on the weight frame bars are differently spaced from those on the poise frame, and when the weight frame is at the top of its stroke it carries all of the weights clear of the poise frame; a small movement downward transfers one weight to the poise frame, the beveled surfaces on the brackets centering the weight if it is displaced sideways by a too sudden movement. A further movement transfers another, and so on—that is, the movement of the weight frame in either direction transfers the weights singly and successively from one frame to the other. The weights *f* and *g* are shown carried by the poise frame, *j* and *k* by the weight frame, while *h* is being transferred from one to the other.

The operating hand lever is provided with a notched segment into which a click spring plays, so that the operator feels when he has moved the lever the right distance to transfer a weight without having to watch the indicator, as formerly, and the arrangement of the six bars surrounds the weights by a cage that effectually prevents any displacement and consequent interruption of the test, as sometimes occurred when the weights rested on simple shelves secured only by short pointed pins. There is hence no necessity for opening the glass case that encloses this part of the scale, and the weights are never exposed to any risk of alteration. The weights in the first poise frame have a value of 100 lbs., the next frame carries weights of a value of 10 times as much, or 1,000 lbs., the next 10,000 lbs., and so on, and the readings are summed up by a series of segments connected to the several operating shafts and provided with figures denoting the number of weights on each poise frame. A horizontal slot in a vertical plate near the upper left-hand corner of the scale is so placed that the reading of the figures shown through this slot denotes the number of pounds pressure applied to the specimen.

There is no calculation required. Those weights show right alongside of the index, and at the same time the centrality of the figures in that slot show at once whether the operator has moved the operating lever of the weight frame to the right point. Now, there is no rubbing on any part of the scale. The movement of the flexible plates and of the fulcrum plates of course requires power. It takes force to move them. But as the plates are made so that with the greatest stresses that come on them they are away within the elastic limit, they will give that force back on returning to the position of equilibrium, and no matter which way the needle is disturbed from the zero point, it will return to it again. The only friction about the machine that may be considered friction at all is that of the transfer of friction from this large chamber, which receives the weight, to the small or reducing chamber in the scale case, and in the smallest scales the motion of the point of the needle, which is about 2 in., is in the neighborhood of 360,000 times the motion of this piston, and on the large machines may be as much as 6,000,000 as much. That is based on the ratio of the levers and the ratio of the areas of the two cylinders. Of course there is another factor which comes in to increase the motion of this small piston, and that is the spring of the parts between this support of the scale in that scale frame and the upper support there. That material, of course, stretches, and the stretch due to the elasticity of that material and the compression of the parts *G*, *H*, and *C* 1 *C'* is more, actually, than the motion due to the mechanical ratio of the parts.

The Emery testing machines are now made horizontal instead of vertical; in the first place, to make all sizes of machines of one type; and, in the second place, to get certain advantages in overcoming the shocks of recoil. In all but the very smallest size of machines, the weighing head and the hydraulic cylinder or straining head are carried and aligned by the top surface of a wrought-iron bed, as shown in this view of a 200,000-lb. testing machine, the straining head on the right hand and the weighing head on the left, back of which stands the scale, and to its right is the pump; in the foreground are the parts of the tension holders.

The weighing head, fig. 5, consists of two circular or annular beams 65 and 69, firmly secured together by bolts placed around their periphery and by the straining screws which pass through both beams and clamp them by a shoulder and nut. This head and the straining head fit easily upon the bed, which maintains the axes of the two heads in the same straight line. A drawbar, 70, is secured in the axis of these beams by two thin annular steel plates, 72, bolted against shoulders near the ends of the drawbar and secured firmly in recesses formed in the outside face of each beam. These plates hold the drawbar securely in line with the axis of the machine, while permitting a free motion to a limited extent in the direction of the axis. The projecting end of the drawbar is provided with a screw thread by which the compression platform or the tension holder is secured to it. The drawbar is enlarged in the middle, and against each of the two shoulders thus formed is secured a thin annular steel plate, 73; these plates are for the purpose of carrying and centering the hydraulic support, which is made annular instead of circular, as shown in fig. 1, and is placed centrally about the axis of the drawbar, so that end stress on the drawbar is resisted symmetrically by the hydraulic support, the part corresponding to the cylinder being secured to one plate and an abutment ring secured to the piston being secured to the other plate, while the cylinder and piston are also separately coupled by flexible plates. By this means the hydraulic support is maintained in fixed relation with the drawbar laterally, while it is left free to move relatively to it in the direction of its axis through the small distance required. On each side of the hydraulic support steel collars, 71, are screwed and secured to the drawbar; these collars are provided on the periphery with a series of ribs (see fig. 7), parallel with the axis of the drawbar, and which lie between without touching, similar ribs projecting from the interior surface of the annular beams. The ends of all these ribs on the two beams and the collars are accurately faced to true planes at right angles to the axis of the drawbar, and the distance between the two extreme faces of the hydraulic support is made slightly less than the distance between these two planes. Movement of the drawbar in either direction carries the hydraulic support against the ends of the ribs in one annular beam, and brings the ends of the ribs on one of the collars on the bar against the opposite side of the hydraulic support, and produces pressure on the contained liquid which is transmitted through the pipe 63 to the small hydraulic chamber in the scale. For the purpose of ensuring that everything about the hydraulic chamber has a solid bearing, it is necessary to produce an initial loading of about 5 per cent. of the

maximum load, which is done by applying a definite spring pressure to move the drawbar in the direction in which the stress to be applied to the specimen will move it, and after this the scale is balanced in the usual way by sliding weights on the poise beam. In order to prevent the shock of recoil, resulting from the rupture of a large specimen of high steel, from doing injury to the thin brass plates in the hydraulic support, the abutting pieces 64, of the support which rests against the ribs in the annular beam 65, when strains of tension are applied, is made larger in diameter than the hydraulic support proper, and is provided with a spiral or screw face 66, which engages with a corresponding screw face formed on a rotatable ring, 67, fitting in the other annular beam 69. After the initial load has been applied, this ring is rotated by the pinion shaft 68, to bring the screw faces in contact (see fig. 6),

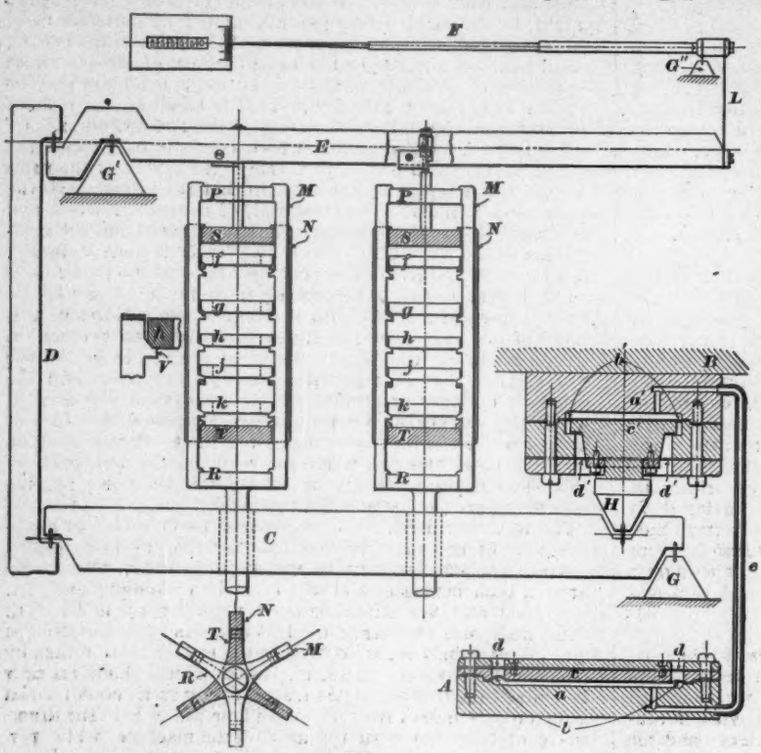


Fig. 1.

GENERAL SCHEME OF EMERY TESTING MACHINE.

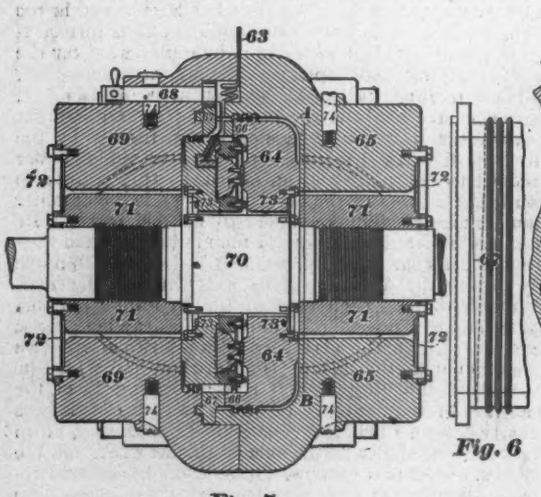


Fig. 5

Fig. 6

Fig. 8

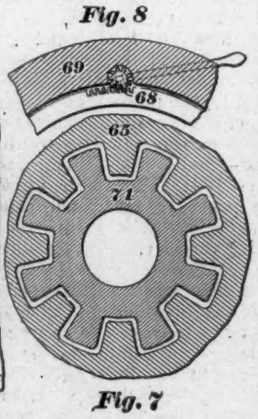


Fig. 7

and the abutting piece 64 is thus clamped firmly to the annular beam against which it rests. When the specimen breaks, its first blow is delivered through the drawbar and ribbed collar to this abutting piece 64, which transmits it through the ring 67 to the rear annular beam 69, and as these beams 65 and 69 are rigidly united, the blow is absorbed by the total mass of these two beams. The hydraulic support is thus thoroughly protected, and these machines can be used regularly for breaking high steel specimens up to the full capacity of the machine without any risk of injury.

The weighing head is returned to its place on the bed after movement due to recoil by a set of spiral springs locked up in boxes secured to the bed, shown at the extreme left-hand end of fig. 2; these springs are strong enough to move the head, and their resistance diminishes greatly the movement due to recoil, while the friction of the head upon the bed rapidly wipes out the oscillations.

The annular beams bolted together, as described, constitute one built-up beam to resist the bending due to the pressure on the drawbar midway between the straining screws. The hydraulic support is thus enclosed in a rigid mass of cast iron and effectually protected against injury from violence or from being gummed up by oil from the straining cylinder, as has occurred with the upright machines, and the frictionless movement of this support under all conditions of service is thus secured.

The fixing plates of this construction are short and direct, and there is no opportunity after that is once assembled for any tampering with it or any getting inside of it to in any way hamper its movement.

Figs. 9 and 10 show a method of making the hydraulic support for very large machines, or when the annular support just described would become too large to be rated by the support testing machine. In this case the supports are made circular and are grouped symmetrically about the axis of the drawbar; as shown in fig. 9, they may be all coupled together by one pipe or connected, as shown, by individual pipes to one or more reducing chambers in the scale. The cylinders of the supports are secured to the ring 75 and the pistons to the ring 76, which is provided with a screw thread on its overhanging rim, and is clamped by the ring 67, as before described.

Two straining screws 77 are provided (see figs. 15, 16, and 17), fixed firmly to the weighing head and passing freely through bearings 88, formed on each end of the straining head 87; a revolving nut, 89, provided with gear teeth on its periphery is placed on each straining screw between the two bearings 88 formed on the sides of the straining head; these nuts are revolved by the wide face pinions 90, driven through the bevel wheels 92 and 93 by a balancing train of gearing consisting of a gear wheel 96 carrying two balancing bevel pinions (see fig. 17), meshing with two bevel wheels, one on each side of the first gear wheel 96, so that power applied to the gear 96 is by means of the balancing pinions divided equally between the two bevel wheels, and thus imparts equal pressure to the revolving nuts 89 on the straining screws. This arrangement does away with the necessity heretofore existing of having the straining screws of exactly similar pitch throughout their length. With this construction the screws could be of different pitches, the alignment of the heads being secured by the fit of the screws in their bearings and of the heads on the wrought-iron bed or shear; by driving this train of gearing either by hand or by power the straining head is moved back and forth upon the bed to accommodate the varying lengths of specimens; when the head is adjusted to place, the nuts form the abutments upon the screws to resist the movement of the cylinder for strains of compression or extension. The nuts 89 do not fit snugly endwise, as heretofore, but a space of several inches is left between the ends of the nuts 89 and the faces of the bearings 88 (see fig. 15). This provides for the shock of recoil when breaking a long and large specimen, the sudden release of the straining screws from their load when the specimen breaks, together with the force resulting from the sudden contraction of that end of the specimen attached to the straining head, merely give the head a push along the bed and it slides freely until its momentum is absorbed by its own friction, the space between the revolving nuts and the bearings allowing ample room for this travel under the best conditions

of lubrication. This head is thus entirely cut off from the rapid vibrations of the straining screws, and the necessity of making the nuts an exceedingly good fit to both screw and head is entirely avoided.

The straining head is provided with a piston packed to receive fluid pressure in either direction, and the piston-rod passing through a packed bearing in one end is provided with a screw thread, similar to that on the drawbar, to receive the various holders. The fluid is supplied to this straining cylinder through two systems of jointed pipes, which are connected through the valves at the scale case with the presure pump and the tank respectively, so that each pipe acts either as a pressure-pipe or an exhaust-pipe, depending upon the direction in which the strain is to be exerted upon the specimen.

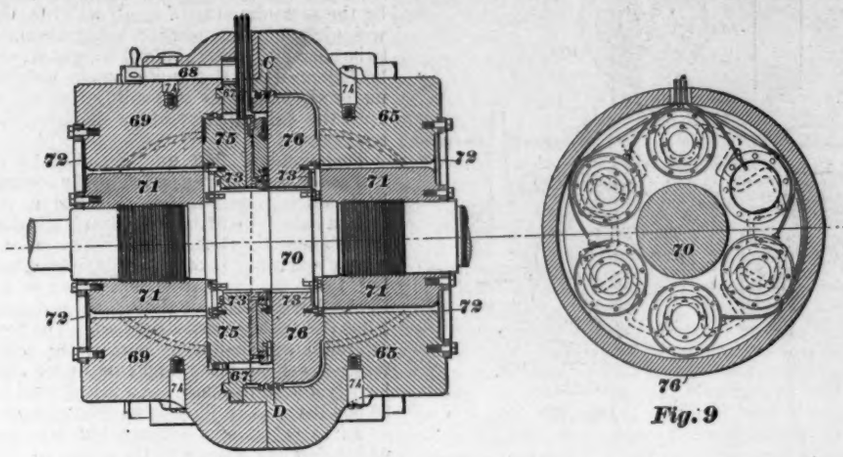


Fig. 10

Fig. 9

The tension holder for gripping specimens for extension tests is shown in section in fig. 21 ; a steel case consisting of the two parts 99 and 107, united by the nut 108, is secured to the end of the drawbar or piston-rod by the screw thread described. The gripping jaws 110 are two cylinders that slide freely in cylindrical holes bored in the case 99 at an angle of about 20° with the axis of the case, making an angle of, say, 40° with each other, the axes of the jaws and of the case being in the same plane. The rear end of each of these jaws is provided with a "T" slot lying in this plane and at right angles to the axis of the case, which engages with a "T" rib formed on a cross-head 106 that fits in a bearing in the case, and compels the jaws to move equally and simultaneously (see fig. 25). The cross-head is provided with a screw thread in its interior to receive an abutment screw 103, which forces the jaws forward and closes them upon the specimen. This screw is operated by an annular worm gear 102, provided in its interior with two narrow lugs (see figs. 22 and 23), which engage with two similar lugs formed on the abutment screw, so that the worm-wheel could make almost a half revolution without moving the screw to which it is coupled by a strong spiral spring, fig. 24. Cylindrical recesses are formed in the opposing faces of the jaws to receive the hardened steel gripping dies 111 and 112, which are made of various sizes and shapes to receive flat, square, or round specimens. The forward half of these dies 112 is made parallel and smooth and of a shape to conform to the section of the specimen ; following this the die 111 has a series of alternate V-shaped ridges and grooves running transversely to the length of the specimen ; the apex of the ridge next to the parallel die 112 being truncated, so that it stands a very little above the surface of the parallel die ; the next ridge is truncated less and stands higher, and so on until the last ridge, which is left sharp (see fig. 26). The dies are closed upon the specimen to be tested, by turning the worm-wheel which, by means of the abutment screw 103 and cross-head 106, pushes the jaws forward until the sharp ridge on the dies rests against the specimen ; further revolution of the worm gear then winds up the spiral spring until the driving lugs on wheel and screw come in contact, when the sharp ridge is forced into the specimen sufficiently to insure that the friction between the dies and the specimen shall be greater than that between the jaws and the case. When stress is applied to the specimen the jaws will be drawn forward, sinking these ridges successively into the specimen until the parallel part of the dies grip it firmly, the idea being that the parallel part will hold with more than sufficient friction to compensate for the depression made in the specimen in the first ridge, and so on to the last, so that a bar of metal can be put into this holder without any preparation and broken without any risk of being broken in the gripped part. As the jaws are drawn forward the spiral spring unwinds and keeps the abutment screw tightly pressed against the cross-head, holding it against the ends of the jaws, and taking up all lost motion, so that accurate centering and gripping of the specimen, no tearing strains, accuracy of weighing at all times, definite weights applied at each movement, and great rapidity for commercial testing is obtained, while when the specimen breaks it will in all cases be firmly held in the dies, and there will be no disturbance nor flying pieces, nor any noise beyond that of the broken piece itself.

The form of pump that we are now using is a three-throw crank type coupled by connections to links vibrating about this center. These links then have the constant stroke due to the crank, which runs about 100 revolutions a minute. At the back there are the cylinders, with valve and check-valve and cross-head there, and the connection here which couples to the link-block sliding in this link. Those links can be raised right up to the center of the shaft, so that the stroke of the pump plunger is stopped entirely, and they can be lowered until the pump has a stroke of 5¼ in., so that by raising and lowering that you get any stroke between the two extremes, or any rate of flow that may be desired.

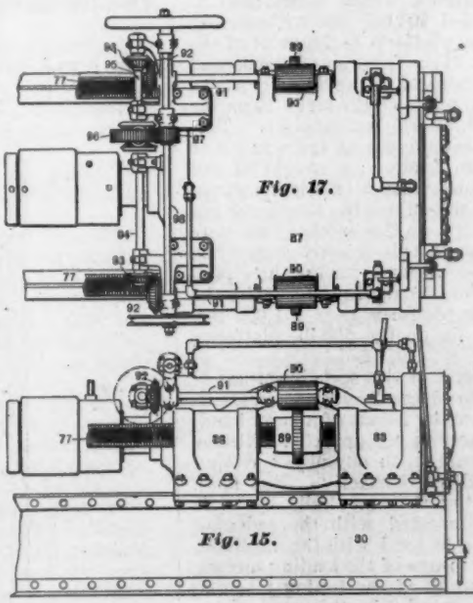


Fig. 17.

Fig. 18.

Fig. 15.

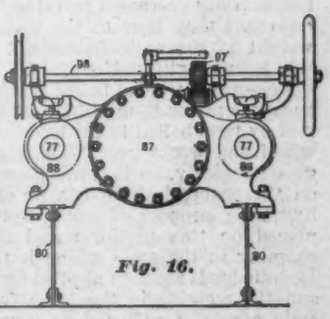


Fig. 16.

A description of the testing machine would not be complete without a notice of the support testing machine, by which all of these testing machines are rated.

This machine is made entirely of steel, in order to secure the greatest possible rigidity, and weighs some 45,000 lbs. It consists of a bed-plate 1, fig. 4, on which are mounted two main levers 2, 2, which carry a heavy platform 6 about 40 in. square ; the outer ends of these levers are coupled to secondary levers 3 and 4, also carried from the bed at their outer ends ; the inner ends of the lever 3 is connected by a rod 9 to a lever 10, fulcrumed at the point 12 to the top plate 13, which is supported by four steel columns 5¼ in. diameter and 77½ in.

long from bed to top plate, 3½ in. diameter in plate. The lever 10 on top is connected by a rod 15 with the poise frame lever 16 in the scale, from which lever all the poise frames are suspended and to which the indicator needle is connected; the second lever 4 is connected by a rod 9 to one end of the equal-armed lever 11, 11, fulcrumed at the point 14 to the top plate

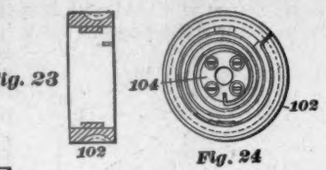


Fig. 23 Fig. 24

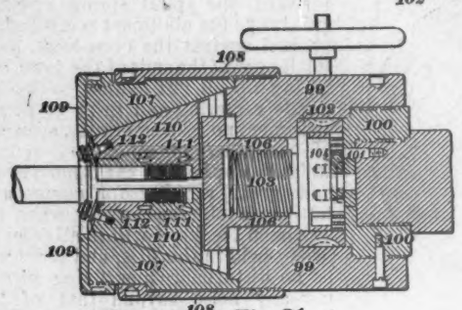


Fig. 21

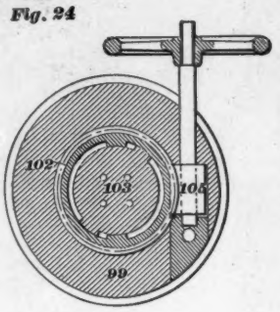


Fig. 22

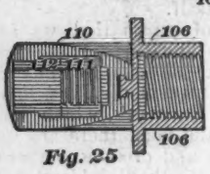


Fig. 25

Fig. 27

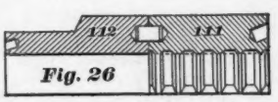


Fig. 26

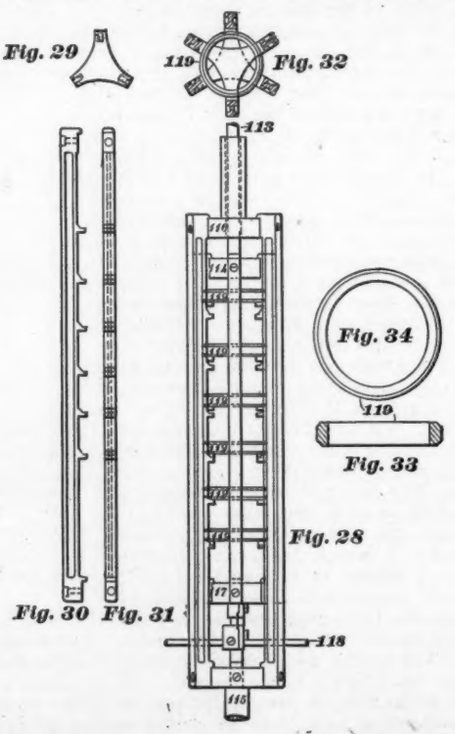
13, and at the point 17 to the lever 10, the lever 11 serving to transfer the downward pull on the rod 9' to the lever 10, so as to have the same effect as the pull on the rod 9. All of the supports and connections of all the levers are the Emery flexible fulcrum plates varying in thickness from about .005 in. at the needle to $\frac{3}{16}$ in. at the platform, which is designed to carry 500,000 lbs., and has carried 600,000 lbs. without any signs of injury, the ratio from the platform to the point of the needle being 306,600 to 1. Close to the fulcrum of the second lever 3, an auxiliary weighing platform 18, having a capacity of 5,000 lbs., is arranged, and hung from the lever 10 on the top plate is another platform 19, of 500 lbs. capacity. This large scale shows conclusively that the use of fulcrum plates instead of knife edges eliminates friction; a weight of 200 grains laid on the main platform puts in motion material weighing more than 25,000 lbs., and moves the needle .02 in., and in all of our experimental work on this machine we were unable to perceive any reduction in this sensitiveness when fully loaded. The same weights are used for the three platforms, being decreased in value for the small platforms by the ratio that they bear to the main platform, thus a 1,000 lbs. weight in the scale balances 1 lb. on the 500-lb. platform, which turns with half a grain.

Pressure is applied to the platform of this scale by means of an upper platen 8, movable by four large loading screws, carried by nuts bolted to the top plate, by means of a large hand-wheel and worm gear. These screws are operated with the greatest nicety, so that the pressure upon any object resting on the scale platform can be adjusted exactly. The main hydraulic support of every testing machine built by us is placed on this platform and connected with the reducing chamber in the scale which is to be used with the machine. Definite loads are then applied by means of the loading screws, and the weights in the poise frames of the testing machine scale carefully adjusted to correspond; in this way every machine is rated accurately by small increments of load up to its full capacity, nothing being taken for granted. For very large machines, where the size of the annular hydraulic supports would be beyond the capacity of this machine, the supports are made circular and grouped around the drawbar as before described, and by testing these supports first separately and then collectively, a testing machine of, for example, 10,000 tons capacity, could be accurately rated throughout its full range, giving an absolute certainty as to results never before attained.

The original rating of this machine presented some very curious problems which gave a great deal of trouble to solve, but ended in convincing us that while the machine is exceedingly sensitive to change of load, it is also, which is a rare combination, equally insensitive to rough usage, such as severe side strains and twists.

The method of rating proposed was to place a standard weight on the platform and balance it by small standard weights placed in one of the poise frames; then to remove this standard and apply pressure to the platform by means of the loading screws until the small weights were again balanced; then to replace the standard and see if it was again balanced by the same amount of small weights, the weighing of the machine being assumed to be correct if this standard weight would be balanced by the same small weights under all conditions of loading, and so on until the full capacity of the machine was reached.

The standard first used weighed 1 ton, and as the loads were applied by the screws, its balancing weight fell off until it required only four-fifths of the small weights to balance it; that it took when on the empty machine; in other words, it weighed but 1,600 lbs., and from that point on up to the full capacity of the scale it weighed 1,600 lbs., neither more nor less. The first inference was that some part of the scale was not solidly fitted, and that under this load it settled to place. An initial load of 30,000 lbs. was applied by steel bars placed so as to act as load springs, but without producing any change in the action of the machine. The machine was then taken apart, but a very careful examination failed to detect any defect. Supposing that the defect might be too small to be readily discovered, an effort was made to exaggerate it and so locate it by packing the lever supports out of level and in wind. The machine required rebalancing, of course, but nothing that we did disturbed the action of the weight, nor the sensitiveness of the scale, nor the regularity of weighing when the critical point was once passed. The screws and gearing actuating the platen were then thought to be at fault, although it was impossible to see how they could cause any disturbance,



but in order to avoid any question, an hydraulic chamber 3 ft. in diameter was made and secured to the underside of the platen, and suspending bolts were provided so the platen could be adjusted closely to place by the screws and all lost motion taken up by the suspending bolts; pressure was applied by pumping liquid into this hydraulic chamber. The results differed in no way from those previously obtained, but by

this time I had determined what the cause of the trouble was —namely, that we had been trying to weigh two kinds of pressure without thinking that they might have different results. I therefore coupled this hydraulic cylinder to a testing machine scale, applied a pressure of about 150,000 lbs. on the platform of the support testing machine, and put weights on the poise frames of the testing machine scale until its needle stood at zero. We then ran the ton weight on, and, as I expected, the needle on the scale immediately moved, indicating a reduction in the pressure. This reduction was produced by the very minute sinking of the platform when the ton weight was applied. Keeping the weight on, the screws were adjusted until the needle stood again at zero, and then the ton weight required exactly the same amount to balance it as when it was put on the empty machine. This settled the whole question; we found the machine was right, its weighings regular under conditions of distortion that would have ruined an ordinary scale, and that the whole trouble came from the fact that we had been trying to weigh screw pressure and pressure produced by gravity without taking into account the disturbance that one produced on the other.

The extreme sensitiveness of this machine serves to show how material supposed to be solid and rigid is in reality continually in motion. In one test the full pressure of 500,000 lbs. was put upon the platform and allowed to remain for 70 hours. At the end of this time it had fallen off to 498,407 lbs., and the falling off still continued at a rate of about 1 lb. in 10 minutes. The pressure was then reduced to 400,000 lbs. Instead of falling off the load increased 40 lbs., in three minutes, and after standing for 10 minutes the load decreased at the rate of 7 lbs. in about five minutes. When the pressure was reduced to 300,000 lbs., in nine minutes the load increased 146 lbs.; with no further indication of increase or decrease for 11 minutes, when it began to fall off very slowly. The pressure was then reduced to 200,000 lbs. In five minutes it increased 307 lbs., and in nine minutes 370 lbs. At this point the load began to fall off very slowly.

It would be very interesting to try if any lapse of time under load would finally bring these movements to rest, but there has been as yet no necessity for making the experiment.

DISCUSSION.

It was asked whether it required the operation of more levers than one to operate the scale. In the old machine it requires one lever for each weight clamped.

MR. BANCROFT: There is one lever for each weight clamped in this. Each frame has a lever which is provided with this click spring. In this scale here each weight is indicated by a small indicator. On the regular testing machine we group those all together, so that the total consumption of the weight is weighed in one line.

MR. ALBERT EMERY: When this load of 500 was put on and remained 70 hours, I suppose it was a solid loading of metal to metal.

MR. BANCROFT: It was a solid loading of metal to metal.

MR. HENRY R. TOWNE: I think it might assist the meeting and prevent a misunderstanding if a point made by Mr. Bancroft at the close of his remarks were explained—namely, that the experience with this machine had developed a difficulty due to the difference in pressures resulting from loads applied by gravity or the screws. It is simply this, that the load is applied through the action of these screws, producing tension in these stays or rods and compression in other parts of the machine. Now when a weight, say, of 1 ton is added to the load on the platen, it tends to substract that amount of load from the strain which is upon the other parts of the machine. It takes it from the tension of these rods and off from the compression of certain other parts, and it is that diminution of the pressure acting on the material of the machine which distributes the resistance of the material to that particular pressure. The pressure is lessened and the elastic action of the parts under the altered pressure is somewhat different from what it was before. The application of the additional load changes the tension or the compression, as it may be, upon the component parts of the machine, and the means of recording that elasticity is so remarkable that it appears on the reading of the scale.

MR. BANCROFT: You can understand it probably better if you consider the machine, instead of being supported on the base, as being suspended on the upper cross-head. Then these columns would have the strain due to the weight of the machine and also the elastic pressure of these rigid blocks between these two platens. Assuming a ton weight put on this platform, it is clear you have thrown an additional stress on those bolts. They must elongate, and that elongation will diminish the pressure between these surfaces to the same extent.

MR. ALBERT EMERY: I would like to remark that I found the same thing in the original testing machine where I laid down the beam forming the bed; laid on that the beam which forms the platform of the fulcrum or scale. A large standard weight was then to be applied to the beam forming the platform, with an exact load of its weight on the measure on the scale; then long bolts running through those two beams and bolting them together were put under a load of, say, 100,000 lbs. strain, and that we carefully balanced and then the standard weight laid on again. I found that no load that I could put on those bolts, which were able to carry the 800,000 load of the scale, would be retained on that scale perfectly that length of time. That is to say, whether I put on 10,000 on those bolts or 100,000, or 20,000 or 500,000, it was immaterial. No load would stand still. They were always yielding, and I had to give up that method and take another one.

MR. BANCROFT: You see we were forced into the same thing.

MR. EMERY: Exactly, because I was not there to tell you.

MR. TOWNE: Mr. Emery was the first discoverer of the fact that there is no such thing as rigidity of material.

MR. EMERY: I would like to add to that remark another one. I have several times conceived the desirability of taking a single bar to form a measure of the friction put on the specimen, measuring the length of the bar when put under compression or tension by strain on the specimen, and recording that length very minutely. But the experience gained in testing this machine, as well as that formerly gained in the original machine, would indicate that the drawbar will never give proportionately to the loads put on it. It will be subject to a very sensible and material error compared to any error of this machine.

A NEW PHOTOGRAPHIC PROCESS.

THE London *Times* some time ago gave the following account of an interesting exhibition at the Camera Club, to demonstrate a new method of photography, by means of which several difficulties and drawbacks are easily overcome. The process is the invention of Mr. Arthur Burchett, who gave in the evening, before a large audience, a demonstration and explanation of the system, by which he has obtained such excellent results. The difficulties which he has succeeded in overcoming, as he said, almost by a happy accident, are chiefly those which have, to a great extent, hitherto stood in the way of most photographers—namely, the translation of the colors of nature into correct monochrome values. The discovery is equally important whether it is applied to landscapes taken direct or to the reproduction of original pictures. It is well known that the latter forms to-day an immense industry, if, indeed, it may not justly be called an art, by means of which photography has become almost the only medium of illustration. Not only so, but the reproductions also of the works of the great painters of all times are widely distributed and made easily accessible. It is therefore of great importance that the originals should be correctly rendered in the translation from color to monochrome; and, although there are already a certain number of capable men, the very simple process which Mr. Burchett has placed before us can scarcely fail to benefit a wider section of photographers, both from its application to this class of work and also to photographs taken direct from nature.

All photographers are aware that certain colors have a greater effect upon the sensitive plate than others. The actinism of blue rays and of the sky, for instance, is so great that it is extremely difficult to prevent their action from being buried during development before the effect of less actinic rays can be brought out. On this account the practice of using two negatives, in order to produce a combination print of sky and landscape, is almost universal. Objects of a yellow color, again, are distinguished in the print by a much lower tone than they should have according to their relative value in the natural scale, and the whole system of tone-rendering has long been considered by painters as a reproach to photography. To remedy these defects it has been customary to interpose screens of a yellow color between the object and the sensitive plate, but Mr. Burchett has discovered that a combination of yellow and green screens or glasses is a more effective and simple remedy. The method possesses also other advantages, among which may be mentioned the cure of halation. The whole of this very simple discovery consists, then, in the use of this combined screen. There is, in fact, little more to describe, but a visit to the exhibition and inspection of Mr. Burchett's pictures will at once demonstrate to photographers its importance and value. We have here landscapes

LOCOMOTIVE RETURNS FOR THE MONTH OF DECEMBER, 1893.

Name of Road.	Number of Serviceable Locomotives on Road.	Number of Locomotives Actually in Service.	Locomotive Mileage. Passenger Trains.	Freight Trains.	Service and Switching.	Total.	Average per Engine.	Av. Train. Passenger Cars.	Freight Cars.	Coal Burned per Mile. Passenger Train Mile.	Freight Train Mile.	Service and Switching Mile.	Train Mile, all Service.	Passenger Car Mile.	Freight Car Mile.	Cost per Locomotive Mile. Repairs.	Fuel.	Oil, Tallow and Waste.	Other Accounts.	Engineers and Firemen.	Wiping, etc.	Total.	Cost per Car Mile. Passenger.	Freight.	Cost of Coal per Ton.
										Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	Cts.	$
Atchison, Topeka & Santa Fé	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Canadian Pacific	617	617	492,480	680,124	286,631	1,459,235	2,365	....	....	....	....	....	80.80	....	....	3.41	12.48	0.36	....	5.71	1.54	23.50	....	....	3.09
Chic., Burlington & Quincy	542	....	....	....	....	1,561,587	2,881	4.97	18.65	....	....	....	95.14	....	....	4.33	6.75	0.25	0.38	7.08	0.07	18.81	....	....	1.41
Chic., Milwaukee & St. Paul	854	....	....	....	....	2,457,945	2,878	....	....	....	....	....	83.37	....	....	3.87	8.46	0.28	....	6.86	....	19.47	....	....	2.42
Chic., Rock Island & Pacific	564	....	474,847	984,892	326,162	1,785,901	3,168	....	....	69.77	86.77	48.69	68.41	....	....	3.18	7.25	0.26	....	6.22	0.40	17.31	....	....	2.06
Chicago & Northwestern	1010	....	802,513	1,546,308	649,873	2,998,694	2,969	....	....	....	....	....	99.45	....	....	3.46	9.19	0.31	....	6.32	0.32	20.10	....	....	1.83
Cincinnati Southern	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Cumberland & Penn.*	23	23	5,639	31,191	....	36,830	1,601	....	....	....	....	....	88.93	....	....	5.71	4.19	0.35	....	....	2.06	12.31	....	....	....
Delaware, Lackawanna & W. Main L.	211	188	70,600	199,308	358,463	628,371	3,342	....	....	....	....	....	102.56	....	....	2.81	7.82	0.39	....	6.11	....	17.13	....	....	1.55
Morris & Essex Division	162	162	178,822	152,442	93,212	424,476	3,619	....	....	....	....	....	74.02	....	....	5.15	11.48	0.33	....	6.55	....	23.51	....	....	3.08
Hannibal & St. Joseph	67	67	....	....	....	262,765	3,981	4.84	16.25	....	....	....	96.78	14.70	7.44	1.91	6.50	0.10	0.30	6.26	0.02	15.09	....	....	1.46
Kansas City, F. S. & Memphis	147	....	94,064	219,111	100,386	413,561	2,813	....	....	....	....	....	71.32	....	....	2.93	6.02	0.23	0.47	7.37	....	17.02	....	....	1.65
Kan. City, Mem. & Birm	42	40	38,004	67,283	11,354	116,641	2,916	....	....	....	....	....	69.11	....	....	2.29	3.83	0.33	0.28	6.94	....	13.67	....	....	1.07
Kan. City, St. Jo. & Council Bluffs	36	36	....	....	....	132,980	3,694	4.95	20.93	....	....	....	77.67	14.45	5.44	2.14	7.78	0.15	0.37	6.18	0.04	16.66	....	....	2.08
Lake Shore & Mich. Southern	591	....	428,062	863,575	435,740	1,727,377	2,922	....	....	73.80	96.06	47.01	72.29	....	....	2.88	5.98	0.07	0.12	6.88	0.17	16.10	....	....	1.55
Louisville & Nashville	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Manhattan Elevated	....	296	773,247	....	66,973	840,220	2,838	....	....	....	....	....	45.87	....	....	2.10	8.80	0.20	....	9.10	....	20.20	....	....	3.83
Mexican Central	148	122	....	....	....	387,907	3,178	....	....	....	....	....	72.23	....	....	6 08	14.16	0.42	0.19	4.39	0.68	25.92	....	....	4.30
Minn., St. Paul & Sault Ste. Marie	103	90	89,694	119,838	27,449	236,981	2,633	4.80	15.75	....	....	....	89.83	....	6.39	4.80	14.79	0.27	....	6.63	....	26.49	4.93	1.75	3.61
Missouri Pacific	351	....	....	....	....	1,015,835	3,455	4.47	18.18	....	....	....	94.38	....	....	4.60	6.62	0.33	1.25	6.25	1.31	20.36	3.74	1.40	1.38
Mobile & Ohio	107	89	75,844	180,192	61,313	317,349	3,565	....	....	....	....	....	73.50	....	....	2.98	5.20	0.22	0.56	5.36	0.82	15.14	....	....	1.43
N. O. and Northeastern	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
N. Y., Lake Erie & Western	637	419	430,771	860,346	264,582	1,555,699	3,713	4.50	22.50	96.90	147.80	65.40	109.37	21.40	6.60	5.10	8.22	0.38	2.34	7.43	1.21	24.68	....	....	1.36
N. Y., N. H. & H., Old Colony Div	....	....	482,762	176,628	218,885	878,275	....	3.80	15.60	....	....	....	67.63	18.00	6.40	3.36	10.15	0.66	....	7.13	0.86	22.16	....	....	....
N. Y., Pennsylvania & Ohio	267	182	127,329	424,449	124,315	676,093	3,714	5.20	16.80	86.70	127.10	79.35	97.71	16.80	7.60	4.85	6.15	0.31	2.91	6 87	0.98	22.07	....	....	1.10
Norfolk & Western, Gen. East. Div.†	....	....	94,383	251,244	52,723	398,350	2,444	5.20	21.40	51.32	141.17	....	97.74	10.42	6.61	5.41	4.09	0.29	....	....	....	9.79	....	....	....
General Western Division†	....	....	98,636	295,736	45,781	440,156	2,651	5.56	17.12	84.00	136.00	....	128.00	15.16	8.56	7.91	4.52	0.27	....	....	....	12.70	....	....	....
Ohio and Mississippi	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Philadelphia & Reading	....	....	423,680	293,956	966,861	1,684,497	....	....	....	....	....	....	87.29	....	....	4.95	4.76	0.31	....	5.78	0.41	16.21	....	....	....
Southern Pacific, Pacific System	736	633	628,914	679,226	245,962	1,554,102	2,112	5.42	13.81	....	....	....	64.62	....	....	5.42	15.79	0.20	2.27	7.24	1.27	32.19	....	....	4.88
Union Pacific	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Wabash	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Wisconsin Central	149	105	115,116	172,249	50,425	337,790	3,264	....	....	....	....	....	93.24	....	....	3.11	10.56	0.21	....	7.23	....	21.11	....	....	2.24

NOTE.—In giving average mileage, coal burned per mile and cost per mile for freight cars, all calculations are made on the basis of *loaded* cars. Empty cars which are reckoned as one loaded car are not given upon all of the official reports, from which the above table is compiled. The Union and Southern Pacific, and New York, New Haven & Hartford rate two empties as one loaded; the Kansas City, St. Joseph & Council Bluffs and Hannibal & St. Joseph Railroads rate three empties as two loaded; and the Missouri Pacific and the Wabash Railroads rate five empties as three loaded, so the average may be taken as practically two empties to one loaded.

* Switching engines allowed 6 miles per hour; wood, construction and gravel trains, 10 miles per hour.

† Wages of engineers and firemen not included in cost.

combined with skies, to which a comparatively long exposure has been given, the blues and the various tints of the clouds assuming their true relation of tone; more unusual still, in photography, we have the full disk of the sun appearing as it appears in nature. With ordinary methods what is termed reversal causes the image of the sun to come out black in the print. Snow landscapes and mists, the greens and yellows of ferns and other vegetation are equally subject to correction under the new treatment, and, generally speaking, the effect of atmosphere is far more easily obtained. With regard to Mr. Burchett's reproductions of paintings, several of which, after well-known artists, are exhibited, it will be sufficient to say that the painters themselves are satisfied; no higher testimonial of the value of the process could be given.

With regard to the practical working of the invention, this consists simply in interposing screens of green and yellow glass between the combinations of the lens. The exposure required is increased by very little, and no special plates or special treatment in development are necessary. It is curious to observe also that the screens appear to have the effect of increasing the quality of the definition, so that a lens working with an aperture of, say, *f*22 will give the effect of using an aperture of *f*40. In his early experiments Mr. Burchett found that a yellow glass alone had little or no effect. A green medium was a decided improvement, but the blues were still defective, and the reds also, though to a less degree. By placing, however, the yellow screen in a certain position behind the green the correction is accomplished. It should be noted that a special kind of green glass is necessary; any tint of green will not suffice.

In the discussion which followed Mr. Burchett's lecture, at which Captain Abney presided, the theory of the process was fully entered into by the president and Mr. T. R. Dallmeyer. It must be conceded that an absolutely new process is due to Mr. Burchett; and in photography especially it is of value to establish priority of discovery. Photographers will not hesitate to thank the discoverer for placing within the reach of all a process as valuable as it is simple.

ACCIDENTS TO LOCOMOTIVE ENGINEERS AND FIREMEN.

THE object of publishing this monthly list of accidents to locomotive engineers and firemen is to make known the terrible sacrifice of life and limb that is constantly going on among this class of people, with the hope that such publication will in time indicate some of the causes of accidents of this kind, and help to lessen the awful amount of suffering due directly and indirectly to them. If any one will aid us with information which will help to make our list more complete or correct, or who will indicate the causes or the cures for any kind of accidents which occur, they will not only be doing us a favor, but will be aiding in accomplishing the object of publishing this report, which is to lessen the risk and danger to which the men to whom we all intrust our lives are exposed.

The only, or the chief source of information we have, from which our report is made up, is the newspapers. From these the following list of accidents, which occurred in February, has been made up. Of course we cannot report those of which we have no knowledge, and doubtless there are many such.

ACCIDENTS IN FEBRUARY.

South Bethlehem, Pa., February 1. — Walter Blank, a fireman on a Lehigh Valley engine, was caught between the tank of an engine and a door-jamb this morning, and squeezed about the hips.

Montreal, Canada, February 2.—Two freight trains collided on the Grand Trunk Railroad at Warwick to-day. The fireman of one engine was seriously injured.

Winamac, Ind., February 4.—A freight train on the Pan Handle Line ran into the rear end of another freight on a crossing near here early this morning. Bruce Ide, the engineer, had fallen asleep and was so seriously injured that he will die. Fireman Merrill was thrown 50 ft., but not seriously injured.

New York, N. Y., February 4.—Frederick Groesbeck, a fireman on the Third Avenue Elevated Road, fell from his engine to-day. He was standing in the side-door when the swaying of the engine made him lose his balance. He fell on the middle track, and received a scalp wound, and several bruises about the body.

Bloomington, Ill., February 6.—An engine on the Chicago & Alton Road blew out a plug from the boiler head 2 miles south of Nillwood this afternoon. Charles E. Drake, the fireman, who was stepping off to shovel coal, was blown out of the gangway and out of the engine. The engineer, Bob Hawks, was scalded about the right hand and other portions of his body. The fireman, besides being scalded on the face, arms, and legs, has severe cuts on the face received by falling on the ballast. His tongue was bitten half in two by the fall.

Columbus, O., February 6.—The last sleeper on the vestibule on the Pennsylvania Railroad jumped the track near this city to-day. The whole train was derailed and the fireman, James Jenkins, was injured.

Doyleston, Pa., February 6.—John L. Hogan, traveling engineer for the Philadelphia & Reading Railroad Company, was struck by a light engine while walking up the tracks this morning. He was picked up in an unconscious condition, and an examination showed his shoulder to be dislocated and his jaw-bone broken. It is also thought he was injured internally.

Burlington, Vt., February 7.—A collision occurred between a freight and passenger train on the Vermont Central Road near here to-night. Engineer Soules, of the freight engine, saw the passenger train come on to his track in time to put on the brakes and jump. He was hurt about his knees, although not seriously. Fireman Mahoney, of the passenger train, was slightly hurt on the side. Fireman James McDougall, of the freight, was hurt in the right hip. Barney Meagan, engineer of the passenger train, was cut over the eye, side of the face, side, and had left shoulder hurt.

Whiting, Ind., February 9.—An express train on the Baltimore & Ohio Road ran into a load of brick standing on a siding, but too near the main track, at this point to-day. T. D. Moore, engineer, was bruised about the head. D. W. Linville, fireman, was hurt about the shoulder.

Lancaster, Pa., February 9.—John Hook, fireman on the Pennsylvania Railroad, had his shoulder wrenched to-day while putting in engine grates which had fallen out of place.

New Orleans, La., February 10.—A collision occurred on the Texas & Pacific Railroad this morning about 140 miles east of this city. The engineer of the east-bound train had orders to meet another train at Rosa. For some reason he ran by Rosa at full speed into the west-bound train. Engineer Penniston, of the east-bound train, was killed.

Great Bend, Pa., February 10.—Moses Conrad, a fireman on the Delaware, Lackawanna & Western Railroad, while dumping ashes off an engine, was struck by the lever and very seriously hurt.

Philadelphia, Pa., February 10.—H. C. Call, an engineer on the Philadelphia & Reading Railroad, was leaning out of his cab and was struck by a freight car on an opposite track in the city to-day. He was so seriously injured that he died from the effects of his wounds.

Buffalo, N. Y., February 11.—Albert King, an engineer on the Lehigh Valley Railroad, fell off his locomotive in the yards at East Buffalo this morning and broke his left arm in two places.

Fremont, O., February 12.—Two freight trains on the Wheeling & Lake Erie Railroad came into collision about 2 miles west of Belleville this morning. Engineers Connell and Stowell of the two engines were killed. Fireman McMullen, of one engine, was also killed. The blinding snowstorm hid the signals, which resulted in the collision.

Temple, Kan., February 12.—A switch engine on the Atchison, Topeka & Santa Fé Railroad exploded its boiler to-day. Engineer Coleman and Fireman Cheatham were injured. Cheatham was badly scalded, and had his right leg cut off. There is no hope for his recovery.

Los Angeles, Cal., February 16.—Train robbers held up a train on the Southern Pacific Railroad near Roscoe to-day. The train was stopped by a flaring of a torch showing an open switch. The engineer jumped and ran and escaped with a sprained wrist and some scratches about the legs. The locomotive jumped the track, and the fireman, Masters, was pinioned in between the cab and the tender and horribly mutilated, crushing his legs.

Des Moines, Ia., February 17.—A collision occurred between a freight train and a passenger engine on the Chicago, Rock Island & Pacific Railroad, near Valley Junction, this morning. The engineers, George Lair and James Wolf, were seriously injured. Fireman Myers was, it is thought, fatally hurt.

Huron, S. D., February 19.—An east-bound express on the Chicago & Northwestern Railway was thrown from the track to-day by a broken rail. George Coon, engineer, and James McNicholl, fireman, were slightly scalded.

Hyde Park, Mass., February 24.—There was a break on one of the engines on the Providence Division of the New York, New Haven & Hartford Railroad to-night, and the fireman was slightly injured by one of the flying pieces.

Kaukauna, Wis., February 27.—An engine on the Chicago

& Northwestern Railroad broke a side rod at Cleveland this morning, shattering part of the cab and injuring R. R. Powers, fireman. Engineer Thomas Gray also had his arm injured.

Bellaire, O., February 28.—A freight engine on the Baltimore & Ohio Railroad exploded its boiler at Nuzum's Mills, W. Va., this morning. Engineer Stevenson and Fireman Law were terribly injured.

Our report for February, it will be seen, includes 22 accidents, in which five engineers and two firemen were killed, and 13 engineers and 17 firemen were injured. The causes of the accidents may be classified as follows:

Blowing out plug	1
Boiler explosion	2
Broken rail	1
Broken side-rod	2
Caught between engine and tender	1
Collision	7
Derailments	1
Falling from engine	2
Repairing grates	1
Struck by ash-pan lever	1
Struck by engine	1
Struck by obstruction	1
Train robbers	1
	22

BUILDING STONE FOR ENGINEERING STRUCTURES.

THE following extracts are from an interesting paper by W. B. Ruggles, C.E., which will interest many readers who are obliged to assume the responsibility for the endurance of engineering structures which are either built in whole or in part, or rest on foundations of that material. The author of the paper says:

"The exhibit made by the census of 1890 shows that the value of building stone quarried in the United States in 1889 was $53,000,000. By the census of 1880 it appears that the value of the corresponding products in this industry in 1879 was only $18,000,000, Ohio at that time ranking first. In the exhibit of the United States Geological Survey in the Mines Building, at Chicago, was a pyramid showing the volume of mineral substance produced in the United States every second. The greatest is bituminous coal, a cube 4.5 ft. each way, of limestone, a cube 204 ft. on each line, and of sandstone, one of 8¼ in. on all lines, were shown. By the report of the Railroad Commissioner in 1891 it is shown that the railroads of Ohio transported 3,500,000 tons of stone and similar material that year.

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"For the uses of an engineer the hardest stones are not always the best. The principal down-town thoroughfares of Cincinnati were paved with granite from quarries near Richmond, Va., but it was thought that this stone wore too little, or was rather polished than worn by the traffic to which it was subjected, and the intersections of Fourth Street were relaid with Georgia granite, which subsequently came into general use for the streets. There are other members of the Society who can give the merits of the two varieties. The published tests for crushing strength show from 68,000 to 84,000 lbs for 2-in. cubes of Richmond granite, and from 77,000 to more than 85,000 lbs. for similar cubes of Lithonia (Georgia) granite, specimens not being crushed at 85,000 lbs., the limit of the capacity of the Navy testing machine at Washington. The Lithonia is reported as a normal granite, composed of quartz, mica and feldspar, with a very low percentage of absorption and free from discoloring matter. In this connection the writer wishes to refer to a statement made to him by Colonel Fladd, then President of the Board of Public Improvements at St. Louis, as to one result of tests made by him on blocks of the Missouri granite from the Gratz Brown quarries. The experiments showed that a wear equal to that on the busiest streets would not reduce an ordinary paving block more than one-twentieth of its depth in 20 years.

"Of less interest to the engineer than to the architect are the stones of darker shades that come from remote quarries. It will be of interest, however, to note that the Carew Building is trimmed with a Lake Superior red stone. The trimmings of the Cleveland, Cincinnati, Chicago & St. Louis Railroad Company offices on Third Street, lately erected, are of West Virginia brown stone, the Greenbrier brown stone, which is used also in the Young Men's Christian Association Building. It is quarried near Hinton, W. Va., and is a stone of attractive shade, but so exceedingly hard as to be expensive to work. It is reasonable, however, to suppose that this excessive hardness gives it its unusual crushing strength, which is reported as 150,000 lbs. per square inch. Its weight is given as 165 lbs. per cubic foot and absorption as one-half of 1 per cent. of weight. The Chamber of Commerce is built of granite, sometimes called 'Quincy granite,' but quarried at Worcester, Mass.

"There is a Killbuck sandstone of pink and brown shades used in a number of Cincinnati buildings. Of this a sample is shown.

"The first bridge erected over the Ohio River at Cincinnati was the Supension Bridge, completed in 1867. The piers of that structure, begun in September, 1856, are, as noted above, built of Buena Vista freestone backed with limestone from North Vernon. In restoring injured cables Mr. Bouscaren, a member of this Society, stated in the paper which he presented to the Society a year or more ago, that much of this masonry had to be torn away to provide for the enlarged cable. His comment on the character of the masonry is that it was poorly laid, but as he does not speak of any deterioration of the stone, it is fair to presume that the interior of the structure was in a tolerable state of preservation. The height of these towers is 230 ft. above low water, or 242 ft. above timber foundation.

"The next bridge constructed was that known as the Cincinnati and Newport Bridge, in 1872. This was built largely of Buena Vista stone from those quarries, particularly the shore piers. The river piers are chiefly limestone from quarries near North Vernon and Greensburg. In these piers this stone has shown a disposition to crack and check. The masonry here, however, may in part be reconstructed with the reconstruction of the bridge proper, the traffic having outgrown the capacity of the whole structure.

"The third bridge was that of the Cincinnati Southern Railroad, completed about 1875. The piers of that bridge were constructed of stone from the Holman Indiana quarries on the Louisville branch of the Ohio & Mississippi Railroad. The piers give no evidence of failure.

"The fourth bridge was that of the Chesapeake & Ohio Railroad, completed in 1888. It is built of Kentucky freestone, probably from near Morehead, and oolitic stone from Salem, Ind., which Mr. W. H. Burr reports as offering a compressive resistance of 12,000 lbs. per square inch, and a ratio of absorption not exceeding 2 per cent. The Kentucky freestone used in the piers is credited with a resistance of 15,000 lbs. per square inch. The Ohio shore pier is built entirely of Ohio River freestone. The river piers are faced with Greensburg limestone backed with Ohio River freestone.

"The last bridge completed is that of the cantilever known as the Central Bridge between Cincinnati and Newport. The piers of that structure of stone are mainly of the Ohio River freestone coped with Bedford oolitic limestone. In the river piers, however, the lower courses of two are of Berea sandstone, and of three of Ohio River freestone with concrete backing up to the belting course, and finished with Ohio River freestone with a coping of Bedford limestone. The reason for this miscellaneous construction is given by Mr. Kaufman, in his paper on that bridge, as follows: 'Considerable difference of opinion as to the reliability of limestone obtainable in quarries near Cincinnati for backing is found among engineers in Cincinnati; but there was no time to investigate, and other quarries were not able to furnish it. There was only available the Bedford stone and the Berea stone, and of these no guarantee of prompt delivery could be made from the Bedford quarries, hence the use of the Berea sandstone. But in the absence of information concerning the comparative elasticity of concrete and Berea sandstone, the use of the concrete filling was not permitted in the higher piers. It is thought that as the Berea sandstone is comparatively soft, if the concrete would compress more than the stone did, an undesirable strain would be thrown upon the facing course of sandstone.

"The first bridge above Cincinnati over the Ohio is at Kenova. Its piers are of Otway stone.

"It will be interesting to note the calculations of engineers as to the amount of strain that stones take in these structures. It is difficult, from the report just quoted on the Central Bridge, to determine the exact weight of the lower courses of the river piers, owing to the form of the cantilever, but it is probably over 2,020 lbs. per square foot for the fifth and sixth piers. Mr. Burr states that the load for the pier of the Chesapeake & Ohio bridge on the Ohio side is 77,200 lbs., and on the Kentucky side 81,200 lbs. for each pile. The load of the river pier, Ohio side, is 13,000 lbs. per square foot, and of the Kentucky River pier 13,047 lbs. per square foot. The writer is unable to get exact figures of the old Newport bridge. The weight coming on the pedestals under the ends of the

main channel span of the Cincinnati Southern Railroad is between 48,000 and 49,000 lbs. per square foot, but these pedestals are of superior stone.

"For purposes of comparison are given the weight on bottom courses of piers of the Sibley Bridge over the Missouri, which is 12,000 lbs. and more per square foot, and of the Chicago, Burlington & Quincy bridge at Plattsmouth over the same river, where the pressure per square foot ranges from 100 to 6,400 lbs., and the pressure per pile for the river pier at 27,000 lbs. per pile. In his lately completed Memphis bridge, George S. Morison estimates the weights of the two river piers as 10,410 and 9,934 lbs. per square foot respectively, but after deducting buoyancy, friction, etc., the pressure on the clay foundation is placed at 3,339 and 3,503 lbs. per square foot. This clay resists compression on an average at one pier of 13,400 lbs. and at the other of 19,300 lbs. per square foot.

"Several years ago Colonel William E. Merrill and John W. Hill were consulted concerning repairs of the Eden Park Reservoir wall. There was some disagreement between them as to the strain that would be thrown upon certain courses in the masonry, the principal difference being as to what were the existing conditions. Mr. Hill's supposition was that the moisture of water sweeping through cracks and crevices would reduce the underlying soil to a state of soft mud, and in that event there would be a pressure at the water side of the wall of 190,000 lbs. per square foot. Colonel Merrill's opinion, however, was that it was improbable that the soil would be reduced to the condition supposed by Mr. Hill.

"The weights coming at the bottom of the masonry in piers of the Suspension Bridge is 7,750 lbs. per square foot, and on the plates under the saddles probably more than 20,000 lbs. per square foot. It is not easy to determine from the report just what the maximum weight might be. In this connection it will be of interest to note that L. L. Buck, who replaced the stone towers of the Niagara Railway suspension bridge with iron towers, calculated that the weight on the rollers of that structure would cause a pressure of 36 tons per square foot on the masonry. Whatever the pressure, it resulted in the destruction of the masonry, which was built of stone from a local quarry. The plans of Messrs. Hogé & White show that the maximum pressure in their arch over Wheeling Creek (Wheeling, W. Va., referred to above) is 533 lbs. per square inch.

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"The increased demand for building stone has led to improved methods of quarrying, and probably the reverse proposition is true also. Usually these stones occur in strata that are broken by cross seams, and the value of the stone for building purposes depends not alone on the material construction of the stone itself, but upon the form in which it can be readily quarried. One of the advantages of the Otway quarries and of the Bedford quarries is that practically any sized piece can be quarried that can be handled. The Knox system, which depends for its principle upon the peculiar form of the drill holes, has reduced the cost of such work materially, and in connection with the electric blasting and the use of channelling machines is leading to large reduction in the cost of the stone at the quarries. Figures are quoted of the cost of quarrying iron ores, which, as a rule, are difficult to remove, at a trifle over 72 cents per cubic yard. The usual price for excavating rock in railroad graduations is 80 cents per cubic yard. The cost of the Government work on the Harlem River was about 40 cents per cubic yard, and the cost of open cut work is stated on good authority to be from 3 to 10 cents for drilling, and from 15 to 30 cents for blasting and excavating. These figures should apply closely to ordinary stone quarrying. Any structure which is intended to be permanent, as such affairs should be considered, is usually built of stone, and it is important that in selecting material for a permanent structure material be chosen that will not only sustain the weights and carry the loads to which it will be subjected, but also stand the effect of water, by which is meant the effect of freezing and thawing, and also of gases which abound especially about cities. Several years ago a very able paper was written by Dr. Thomas Eggleston, of Columbia College, on the cause and prevention of decay of building stone, and for the information of the members of the Society the liberty of referring to some statements in that paper is taken.

"One interesting fact stated by him is that in the purest air carbonic acid exists to the extent of about three one hundredths of 1 per cent. only; but that in and about cities, especially those where coal is used in abundance, this amount is greatly increased; and other authorities are quoted as giving as the result of experiments made by them, that the heat is increased by the reason of the increase of this gas in the winter months. The estimated value of a London winter's smoke is set down at $25,000,000. New York City is said to use in the neighborhood of 5,000,000 tons of coal per year. The imports of coal in Cincinnati in 1890 were 2,500,000 for local consumption. From this at least 35 lbs. of sulphurie acid would be discharged in the air for each ton. This must have its effect upon the stones of buildings. The act of freezing is equivalent, in his opinion, to the blow of a 10-ton hammer. To such causes as this, leading to the disintegration of stone, he adds that of efflorescence upon, or the formation in the stone itself, of soluble salts, and the corroding effect of sand carried by wind at a high velocity.

"It follows that stones which are to be used in structures should be carefully observed as to whether they contain minerals which are already decomposed or are likely to become so. Dr. Eggleston states that stones which are subject to no decomposition apparently in one climate are thoroughly decomposed in others. For instance, he was led to conclude from his examination that limestones are entirely unsuited in the climate of New York for the construction of monuments and buildings to be exposed to the air. Sandstones having a silicious binding are the most durable; those in which the binding material is the oxides of iron usually disintegrate readily. He says, also, that while the amount of carbonic acid in the air and water at any time is extremely small, the accumulation of very minute quantities acting over a large area for a considerable length of time has often been sufficient to dissolve out the whole of the binding material. There is a difference between stone newly quarried and that which has been exposed for sufficient time to lose its quarry water. A good specification for masonry should be to require such seasoning—an ancient practice of architects. It is said to have been required by Sir Christopher Wren that the stone for St. Paul's Cathedral should season for two years before being taken from the quarry. It is, however, urged that the stone should be reduced to its proper dimensions as soon after quarrying as possible. For good sandstone and limestone a serious source of disintegration is from freezing and thawing. The writer has frequently been reminded of this in looking out of his window upon the Masonic Temple, which was built of Buena Vista stone, begun in 1858 and finished probably in 1861. The stone in that building is in a good state of preservation, except about the water spouts and places near the roof, where the ice accumulates in freezing weather. This is probably aggravated by placing the facing stone on edge rather than on its quarry bed—at least the appearance of the stone leads to that conclusion. Nearly all varieties of stone will crush on edge with less load than on their quarry bed."

MARINE NOTES.

Boilers for the "Powerful" and "Terrible."—The Admiralty will fit the *Powerful* and *Terrible* with boilers of the Belleville type. The *Armand Bêhic* and *Polynésien*, two large steamships of the French-Australian line, are fitted with the same type of boilers. These are 10,000 H.P., and are reported to have made faster runs than any British ship of similar tonnage. It is as a consequence of the success with these two ships that the Admiralty have decided to try the same boilers on the two large cruisers that are about to be built.

Electric Gondolas in Venice.—The success of the electric gondolas at the World's Fair has encouraged the builders to reciprocate the compliment which was paid to the United States by Venice, in sending an exhibit of gondolas for the lagoons, by sending an electric launch driven by storage batteries to Venice. Another curious exemplification of the utility of the storage battery is shown in the case of the use of a copper-steel alkaline battery of 384 cells, which draws its current from the street railway circuits, and is used to drive two Waddell-Entz motors of 40 H.P. each, that swing the 520 ft. span bridge of the Omaha Bridge & Terminal Company. The draw weighs between 3,000,000 and 4,000,000 lbs., and is swung in about four minutes.

British Battleship "Centurion."—There are some new and interesting features about the new British battleship *Centurion*, which has just passed through her official trials at Portsmouth. The vessel herself belongs to a new type, there being only one other like her—the *Barfleur*. She is 360 ft. long and 70 ft. broad, with a displacement of 10,500 tons. A belt of steel armor, having a maximum thickness of 12 in., protects the water-line for about 250 ft. of her length, and extends below water to a depth of 5 ft., and above water to a height of 2½ ft. Associated with the belt is a protective deck from 2 in. to 2½ in. in thickness, which is completed at the ex-

tremities by athwart armored bulkheads 8 in. in thickness. The armament consists of four 10-in. 29-ton guns mounted in redoubts; ten 4.7-in. quick-firing guns, of which four are carried in armored casemates; eight 6-pdr. and nine 3-pdr. Hotchkiss quick-firing guns; a complement of field and machine guns, and seven torpedo tubes, two being submerged. The heavy guns are contained in redoubts, which are neither turrets nor barbettes, but may be described as turrets revolving within a fixed barbette. The guns can be loaded at any angle of training, and can be worked either by steam or hand power. Moreover, owing to the arrangement of the shields, they command a range of 42°, without unduly large ports. There are also several new and ingenious devices for insuring a rapid and continuous supply of ammunition. Owing to novelties in construction, the ship was subjected to severe trials which are said to have resulted most satisfactorily. It is announced that hereafter the 50-ton gun will be the largest employed in the British Navy.

Foreign Torpedo Boats.—A correspondent of the London *Times* writes: "The following are particulars of the sea-going torpedo boat *Forban*, which is now being built at Havre by MM. Augustin Normand & Co., and which is designed to attain the extraordinary speed of 30 knots, or 34½ statute miles an hour: Length, 144 ft. 3 in.; beam, 15 ft. 3 in.; draft, 10 ft.; displacement, 130 tons; indicated H.P., 3,200. The vessel will have twin-screws, and will carry two torpedo-ejectors and two 1.46-in. guns. The *Forban* will be by far the fastest craft afloat. The *Chevalier*, a torpedo boat of the same length, but of only 2,700 indicated H.P., was recently delivered by MM. Normand, and has attained a speed of 27.22 knots.

"The boilers which give these striking results are a specialty of the firm of Normand, and are, it is understood, to be adopted for the new British torpedo boat destroyers *Janus*, *Porcupine*, and *Lightning*, under construction by Messrs. Palmer & Co., of Jarrow, and for the *Rocket*, *Shark*, and *Surly*, under construction by Messrs. J. & G. Thomson, of Clyde Bank.

"Of the numerous sister ships that have been ordered, the *Conflict*, *Teazer*, and *Wizard*, building by Messrs. J. S. White, of Cowes, are to have Mr. J. S. White's boilers, constructed by Messrs. Maudslay, Sons & Field; the *Fervent* and *Zephyr*, building by Messrs. Hanna, Donald & Wilson, of Paisley, are to have locomotive boilers; the *Swordfish*, building by Sir W. G. Armstrong, Mitchell & Co., is to have Babcock & Wilcox's boilers; and, probably, the *Skate*, *Starfish* and *Sturgeon*, building by the Naval Construction & Armaments Company, at Barrow, and the *Sunfish*, building by Messrs. Hawthorn, Leslie & Co., of Hebburn, will have Blechynden boilers. Yet other vessels of the class will have Yarrow, Thorneycroft, Belleville or Du Temple boilers; so that the trials of the destroyers should afford a fairly good indication of the merits of the various British and French systems.

Electrical Canal-Boats.—The Cataract General Electric Company has secured a permit from the Superintendent of the State Department of Public Works for the privilege of putting in an electric plant along the lines of the State canals by which boats may be operated with electricity. The permit authorizes the Company to enter upon all lines of the State for the purpose of constructing on, over, or under either canal bank, a system for propelling canal-boats with electricity without interfering with the present mode of operation. A central power-house may be erected. The rate is to be subject to modification and review by the State Superintendent of Public Works, but it is stipulated that the rates shall not exceed $20 per electrical H.P. for any season of navigation. The important provision is that the Company, so long as the wants of the State are supplied, may employ its electric plant along the line of the canal in furnishing electric light, heat, and power for distribution to any point or points beyond the line of the canal, and may thus furnish electricity for lighting and power purposes in all of the cities and villages along the canal. The Company must furnish to the State, free of charge, sufficient power to operate motors to open all gateways leading to and from locks, and also electric lamps sufficient to properly illuminate such locks at night. It is also stipulated that its plant must be in operation on the Erie Canal between Buffalo and Albany within three years, or the privileges accorded by the permit will be forfeited. The Company will obtain its electric power at Niagara Falls from the Niagara Power Company, and will transmit it to Albany along the line of the Erie Canal. There is another company having the same directors as the Cataract Company called the Erie Electric Towing and Power Company, with their principal office in New York. This Company will construct and put in operation as soon as possible a half-dozen tugboats operated by electricity, either on the storage or trolley system, with a view of showing the adaptability of electricity to canal navigation. These boats will also tow for a moderate consideration any horse-boats, the captains of which desire to avail themselves of such methods of navigation.

Test of the United States Dredge "Ram."—The Bucyrus Steam Shovel & Dredge Company, of South Milwaukee, Wis., have recently completed a powerful self-propelling suction dredge for the Mississippi River Commission, and the machine has lately been tested, the actual work fully meeting the requirements which were made upon it. These were that the practical capacity should not be less than 300 cub. yds. of solid matter per hour, when discharging over a bar or bank not less than 10 ft. above the water surface, and with point of discharge not less than 300 ft. distant. The dredge had to be capable of working effectively in stiff clay and sand, of cutting its own way through a solid bank above water, of working in all depths down to 30 ft., of discharging material on either side to a distance of 1,000 ft., and over a bank 35 ft. elevation above bottom of cut, and of admitting easy and rapid handling in a narrow channel in shoal water and in a rapid current. The dredge was built on the Ohio River, and proceeded to its destination in Louisiana under its own steam, making a speed of 7 miles per hour, towing 11 pontoons. The test for capacity took place on January 29, under supervision of Captain John Millis, on the part of the Government, and Mr. A. W. Robinson on the part of the builders. The volume of discharge was measured by diverting the stream into water-tight bins upon a large flat scow fitted with suitable sluices and gates. Samples of the discharge were taken in this way for periods of 30 seconds every half hour during the test. At the conclusion of the test the contents of the bins were allowed to settle undisturbed for 40 hours, and the contents accurately measured. Then the water was drawn off and the residue measured. This residue was found to consist of semi-fluid mud on top and solid material in the bottom, and was therefore measured separately, with results as follows:

Duration of measured trial	3 hours.
Total time pumping into scow	3 minutes.
Total measured volume	70.76 cub. yds.
Volume of residue after settling 40 hours	38.37 cub. yds.
Percentage, residue total volume	54
Rate of discharge of residue, cubic yards per hour	777
Volume of semi-fluid mud drawn off after 40 hours	16.37 cub. yds.
Volume of solid matter left	22 cub. yds.
Semi-fluid mud reduced to solid material	9.82 cub. yds.
Total solid material discharged in 3 minutes	31.82 cub. yds.
Percentage of above to total volume	45
Rate of discharge of solid material, cubic yards per hour	636.4

The dredge was making a cut 100 ft. wide and 14 ft. deep, discharging 10 ft. 6 in. above the water at the prescribed distance, and the result, as will be seen, was more than double the guarantee. This large output was obtained steadily, and no attempt was made to sort the material. In this dredge the material is excavated and fed uniformly and continuously to the pump by a rotary steel cutter-head of improved form, so that the pump and pipe is always worked up to its maximum carrying capacity, and the percentage of solid matter under perfect control. The dredge was built from the designs of Mr. A. W. Robinson, the Chief Engineer of the Bucyrus Company.

PROCEEDINGS OF SOCIETIES.

Association Engineers of Virginia.—At the February meeting Mr. C. C. Wentworth opened the meeting with the topic of the evening, which was Highway Bridges. He gave complete tables of weights of trusses and methods of obtaining weights for various loads, also strain-sheet blanks for various forms of trusses, tables of sections from which the approximation for each chord could be obtained. Standard shop drawings were also exhibited showing eye bars, chord members, etc.

Liverpool Engineering Society.—At a meeting on February 14 Mr. Morgan read a paper on Street Pavements, in which he paid more particular attention to experimental pavements and the various kinds that have been laid, with a view to mitigate the noise of traffic, such as asphalt and wood pavements, giving details of their wear and cost, and the comparative merits of different classes of woods used for paving. Statistics were also given showing the relatively greater wear of steel tramways in comparison with granite sets.

Northwestern Railway Club.—At the regular meeting on February 13, papers were read by Mr. George Dickson, of the Great Northern Railway, and Mr. H. L. Preston, of the Omaha Railway, on Steel *versus* Iron Axles for Locomotive and Car Use. Mr. Dickson's paper took up the record of certain axles which have been in use on the Great Northern Road that offered a fair basis for comparison, and was somewhat in favor of steel axles both for safety, convenience, and cost. In the discussion, Mr. L. R. Pomery took the position that an alteration of the structure of iron bringing about a condition similar, if not exactly corresponding to the crystallization, can be brought about by vibration, and gave examples of crane chains and spokes of certain wrought spoke wheels to illustrate his position. Other members advanced the idea that a muck bar axle is preferable to one made from scrap. The subject for the next meeting will be Brick Arches in Fire-boxes, and Care of the Passenger Trains at Terminals.

Engineers' Club of St. Louis.—At a meeting on February 21 there was a discussion in regard to the location of boulevards in the central part of the city, followed by a paper on the Manchester Ship Canal by Mr. John Dean, who gave a synopsis of the plan of reorganization and the work which has been done, and with which most of our readers are familiar. The canal, he said, is 26 ft. deep, 28 ft. on the lock-sills, with a width of 120 ft. at the bottom and 170 at the waterline. It is lighted throughout by electricity, so that it can be used by night and day, and the clearance allowed on the bridges is 75 ft.; the time of passage from six to seven hours. At the meeting of March 7 Mr. L. Holman gave an address on the new St. Louis Water-Works, giving a short *résumé* on the early historical, with the present and future aspects of the work. The first agitation for water-works in St. Louis began in 1829, and they were built between 1833 and 1836 with a wooden reservoir 100 ft. square. The pipes were all of lead and put in by the city. The present system was put into service in 1872, and there are now 420 miles of pipe in the city.

Engineers' Club of Cincinnati.—The report of the Secretary for the year ending December 21, 1893, has just been issued, and contains a list of the papers which have been read during the year, and which were as follows: Country Roads; the Position which their Improvement should Occupy in the Internal Development of the United States, M. D. Burke; Suggestions on the Improvement of the Miami Canal, Major L. M. Hosea; Peculiarities of Numbers, Oswald Dietz; Proposed Plan for Disposal of Overhead Wires in Cities, Colonel Latham Anderson; Sidewalk Improvements in the Vicinity of Cincinnati, E. F. Layman; Underdrainage as a Structural Feature in Engineering Works, Colonel Latham Anderson; Building Stones of the Vicinity of Cincinnati, W. B. Ruggles; Ladies' Night—Reading of selections from the manuscript of "Blennerhassett," Professor W. H. Venable; vocal and instrumental music; Telford *versus* Macadam—Which was Right? Colonel Latham Anderson; Contractors *versus* Specifications, Charles E. Ewing; Construction of the Norwood Reservoir, C. N. Miller. Annual Address: Engineering Progress During the Past Year, Colonel Latham Anderson.

At a recent meeting of the Club Mr. M. D. Burke read a paper on the ship canal from Cincinnati to Toledo, in which he reviewed the question of the construction of a canal of sufficient dimensions to allow the passage of boats and barges of large sizes. He discussed the question from the standpoint of the requirements necessary for a navigable water-way connecting the lakes with the Ohio River, the physical conditions required to make such a line practicable, and the benefits to be derived from its construction.

Civil Engineers' Society of St. Paul.—At a meeting on March 5 Mr. C. J. A. Morris addressed the meeting on the subject of Coal Docks and Coal Handling Plants. He illustrated it by maps, plans, photographs, etc., of the belt railway and coal dock of the Northwestern Coal Railway Company, which is now being built at Superior. The tract of land which it occupies is more than 75 acres, and is being filled to an average depth of 10 ft. It is bounded by cribs of 12 in. square timber hemmed in by a row of 60 ft. piles driven to 4 ft. centers. The cribs are 22 ft. deep, 24 ft. wide, and are sunk in 250 ft. sections with material, principally sand, which has been raised by a hydraulic dredge that is capable of moving 300 cub. yds. of solid matter per hour. The dredge consists of two scows of 5½ ft. draft connected by a huge joint. The end of a 20-in. section pipe carrying a revolving cutter, which masticates anything in its way except solid rock, ranges vertically 28 ft. and horizontally 80 ft. by the swinging of the smaller scow. The main boat, which is 95 ft. long, is anchored by fore-and-aft spuds. If the dredge is swung from a forward spud a range of 150 ft. is secured. The 400-H.P. engine works a centrifugal pump, and cutter material may be carried through the 18-in. delivery pump for a distance of 3,500 ft.

Engineers' Club of Philadelphia.—At a meeting on March 3 Mr. W. B. Riegner read a description of the New Falls of the Schuylkill Bridge of the Philadelphia & Reading Railroad Company, and Mr. John C. Trautwine, Jr., called the attention of the meeting to an interesting problem which occurred in supplying the village of Frackville from the Mud Run Reservoir in Schuylkill County. The water was fed through a 10-in. pipe, for a distance of 8,000 ft., to locomotives and fireplugs in the village. The fall in the pipe was 40 ft., and the head in the reservoir 20 ft. At the village this pipe separated into two branches 6 in. in diameter, one 3,200 ft. long, running to the village of Mahanoy Plain, with a fall of 340 ft., and the other about 1,500 ft. long, running to the head house of the plain, and in this distance first rising 2 ft., then falling about 10 ft. to the upper story of the head house, and 15 ft. further to the cellar. The difficulty experienced was that, owing to the much greater head in the long pipe, the valley at its end got all the water, leaving practically none for the head house at the top of the plain. Mr. H. K. Nichols, Chief Engineer of the Philadelphia & Reading Railroad, remedied the trouble by the simple expedient of introducing in the long pipe, just below the branch, a siphon about 18½ ft. high, provided at the top with a blow-off cock, by which the air is allowed to escape when it accumulates in too great quantities.

New York Railroad Club.—At the March meeting two papers were read. One by Mr. West, Superintendent of Motive Power of the New York, Ontario & Western Railroad, on "What is an Economical Load for the Locomotive from the Standpoint of the Motive Power and Transportation Departments?" and the other by Mr. Weston, Superintendent of the West Shore, on "From what Class of Employés Should Locomotive Firemen be Selected?" It cannot be said that any real decision was reached in the discussion of either paper. Many instances of overloading and bad practice were cited, but no one offered a practicable remedy. The second paper fared about as badly. Mr. Weston laid down the four following propositions:

"First proposition: The locomotive fireman should invariably be selected from employés engaged in road service.

"Second proposition: Locomotive firemen should be selected from among the men filling the position of head brakeman on freight trains. This proposition anticipates that the position of head brakeman on freight trains shall be filled by men who have been especially selected with reference to their fitness for firemen, and that while they are filling the position of head brakeman they will be on probation or trial for the purpose of ascertaining, as nearly as possible, whether they are the right kind of timber to grow up to be engineers or not.

"Third proposition: In selecting firemen the man's promise of becoming a good runner should be the controlling consideration, and that everything else should be subordinate to this essential requisite.

"Fourth proposition: As a general rule, the fireman who has the least promise of becoming a satisfactory engineer is the one who is selected from the ranks of the engine wipers."

But in the discussion there was a strong exception to taking firemen exclusively from the ranks of the head brakemen, and men ranging from farmers' boys to round-house wipers and helpers were reported as having made excellent firemen.

PERSONALS.

Mr. W. H. Rosing has been appointed Master Mechanic of the First District, First Division of the Denver & Rio Grande Railroad, with an office at Burnham, to take the place of Mr. Quimby Lamplugh resigned.

Mr. Rollin H. Wilbur, General Superintendent of the Eastern Division of the Lehigh Valley Railroad, has had his jurisdiction extended so that it now covers the Northern Division, and after March 5 the superintendents of the North Branch, Seneca, Auburn and Buffalo Divisions report to Mr. Wilbur as General Superintendent at South Bethlehem, Pa.

CONGRATULATORY.—An event of much importance to a number of people occurred just after THE AMERICAN ENGINEER went to press last month. Mr. Clarence B. Howard, of New York, and Miss Minnie Morey, daughter of Mr. and Mrs. Franklin Morey, of Denver, were married in that city on Thursday evening, February 22, in the Twenty-third Avenue Presbyterian Church. The Bride is said to be beautiful and accomplished, and interested in church and charitable work. The Groom is associated with the Safety Car-Heating and Lighting Company, of this city, and holds a responsible position and is well known to many of our readers. May he realize the truth of the saying of the wise man from the East, who wrote that "those who have wives are blest with good fortune. Wives are as friends who; by their kind and gentle speech, soothe you in your retirement. In your distresses they are as mothers, and they are refreshment to those who are travelers in the rugged paths of life."

May felicity attend their steps.

NEW STONE-BREAKING MACHINE FOR ROAD-MAKING.

Manufactures.

A NEW STONE-BREAKING MACHINE FOR ROAD-MAKING.

THE stone machine illustrated in our engraving is of special interest to contractors, engineers and others having to do with the breaking of stone for macadam and ballast. It was built especially for this class of work by the Farrel Foundry & Machine Company, Ansonia, Conn , and is one of a number of such machines recently furnished prominent contractors and for which there continues a general demand. While it does not depart in its general construction from the familiar design characteristic of the Blake style crusher, as long built by the Farrel Foundry & Machine Company, it does differ essentially in the distribution of weight and material used in its manufacture.

The Farrel crusher, as usually built, consists briefly of a strong iron frame, near one end of which is a powerful movable jaw of iron. By means of a toggle-joint and eccentric this jaw is moved back and forward a slight distance from the frame. As the jaw recedes the opening increases and the stone descends; as it approaches the frame the stone is crushed. By an adjustable toggle-block the length of the stroke of the jaw can be adjusted to the size of any stone or particular product, and this while the machine is in motion. The needs of contractors for the class of work indicated demands a machine that is unusually strong and substantial, and so arranged that the wearing parts are easy of access and readily renewed. It was to meet just such requirements that the crusher presented was built, and the results have proved very satisfactory.

In this machine the pitman and swing-jaw are of steel, which enables the Company to build them lighter and at the same time much stronger than would be possible were they constructed of cast iron. The swing-jaw shafts and eccentric shafts are larger than usual, the jaw-plates are of the best quality of charcoal iron, and the cheeks and other wearing parts are, with the exception of the plates, of steel.

The machine is simple and positive in its working. This machine is made in sizes as follows—namely, 15 in. × 9 in., 20 × 10 in., and 30 in. × 13 in. It is of interest to add that over 100 medals have been awarded crushers made by the Farrel Foundry & Machine Company at various expositions.

PETROLEUM IN JAVA AND SUMATRA.

WE have received from Mr. William Warren a communication anent the Sumatra and Java petroleum wells, in which he states that the average output there is 228 barrels per well per day, as compared with 241 barrels in Russia, and (up to the end of October, 1893) 59 barrels per month in the United States, while in Burma a well giving 25 barrels daily is considered a big well. The amount of the exports east of Suez exceeds 20,000,000 cases of oil per annum—a matter of paramount importance to Sumatra, as *good* oil cannot be obtained elsewhere in the East.

The Dordtsche Petroleum Company of Java commenced operations with a capital of 350,000 fr. (£29,250), and, it is stated, have since that date paid dividends aggregating 80 per cent. of the paid-up capital as above. At Wonokrona, 5½ miles from Soerabaya, a large oil refinery has been established which gives employment to about 2,000 men. The crude petroleum, which is obtained from a number of oil wells—about 27—which have been drilled to depths varying from 100 to 800 ft., in the village of Djabakotta, situated about 4 miles from Wonokrona, is conveyed to the refinery through a pipe line, although the oil is thick or heavy—namely, 23° to 42° Beaume, the warm climate keeping it fluid.

In another village (Gogoa) are other oil wells, the deepest of which is that 1,850 ft. deep, producing gas, the pressure of which is 438 lbs. per square inch, which is used as fuel for boilers and other purposes.

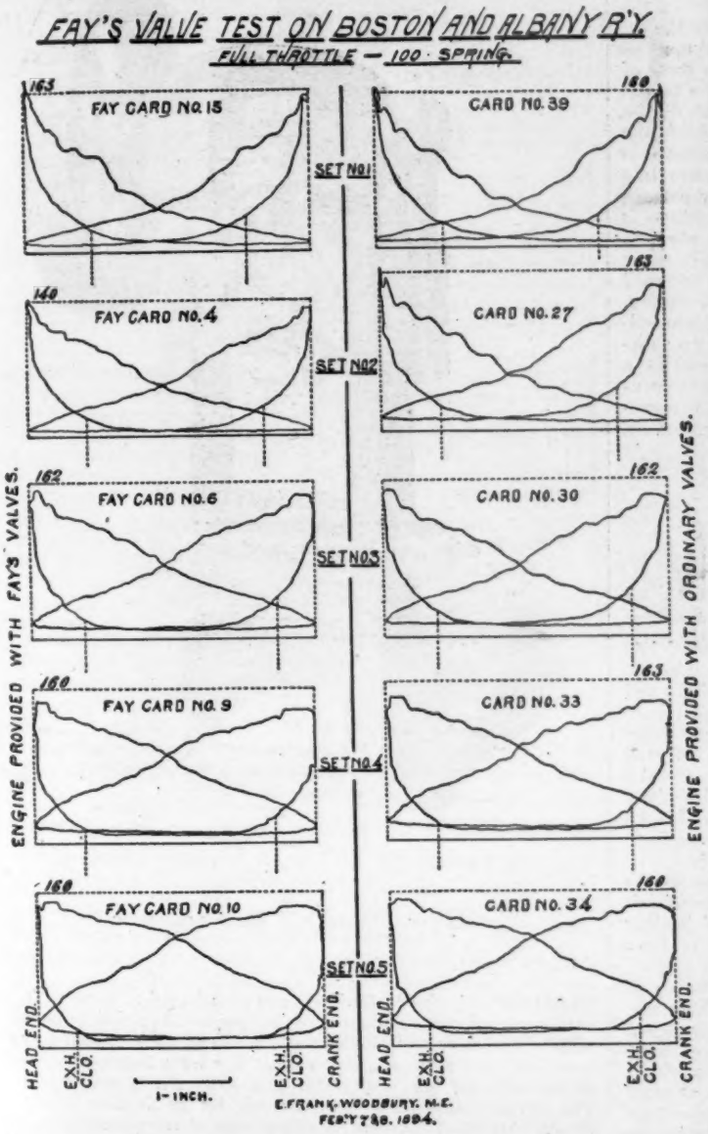
The Dordtsche-Java Petroleum Company, already mentioned, is said to possess drilling rights in Java over 150,000 bouws (262,800 acres, or, say, 410 square miles) of oil lands there, its present monthly output of refined oil being 45,000 cases, which it is expected will be doubled in a very short

time. Other petroleum concessions have been taken up and are being worked in Java, as at Gunong Sarie, the rights of which have been secured by a Chinese family, Tuan Lok, who are working it with a capital of 300,000 fr. (£25,000), the entire interests of which, however, are now said to be taken over by a large Chinese company with a capital of 4,000,000 fr. (£333,330). The area of the concession held by this company is given as 250 bouws (438 acres, or, say, seven-tenths of a square mile). The depth of their wells varies from 75 to 350 ft.; one of the shallowest, only 75 ft. deep, gives 396,000 liters (or, say, 11,000 cases) of oil daily, the density of which, as crude, is 17° Beaume, the wells being drilled at a cost of 2 fr. (say, 1*s.* 8*d.*) per foot for the first 150 ft. of depth. This Company, which is in active operation, has so far produced only an inferior product, for want of suitable new plant, some of which has now been ordered from Germany, of a monthly capacity of 1,000,000 liters; or, say, 1,000 cases daily. Some 12 wells are about to be drilled at several other places in this oil-bearing district, for which concessions have been granted and syndicates formed, as at Pasoeroen, Kedir, Toeban, and Rembang in Banjoewangie, Madura Island, etc.

The chief merit of the Java crude petroleum consists in the great value, both of the fair proportion of kerosenes, but especially of the unusually large proportion of valuable by-products as lubricating oils and paraffins, differing very considerably from the Langkat petroleums obtained in the neighboring island of Sumatra, these latter yielding about double the proportion of kerosenes and correspondingly less paraffins. The Royal Netherlands India Petroleum Company of Sumatra is at present producing about 1,600 cases of refined oil daily from three wells only—the promise of a large oil field in Langkat being, apparently, such as to make it more than ever regrettable, from a British point of view, that Lord Castlereagh should have bungled these rich islands out of the hands of the British into the hands of the more fortunate and successful Dutch.—*Commerce.*

FAY'S ENGINE VALVE.

Mr. Henry R. Fay, of 8 Exchange Place, Boston, Mass., has recently brought out a modification of the ordinary D slide-valve that serves to reduce the compression in locomotive cylinders. Its chief value is to be found when the engine is running at high speeds and the compression is excessive. It can be applied to any engine by drilling holes at the end of the bridge, at such an angle from the valve-seat to the bore of the cylinder that the piston packing will reach the first of the holes when a groove cut in the face of the valve, and extending across from one hole to the mate at the opposite end opens into the admission port after cutting off. In the applications that have thus far been made, these holes have been ⅜ in. in diameter, sufficient stock being left between the hole and exhaust to cover the groove in the valve. Each of the grooves in the valve is provided with two end cavities in the side of the valve, which are cut so as to reach the extra cylinder ports when exhaust takes place on the opposite end. A communication is thereby opened with the other end of the cylinder, allowing the compression to pass around the piston to the other end of the cylinder and exhaust.



The valves have been placed on a number of engines on the Boston & Albany Railroad, and a test was recently made with one of them for the purpose of determining the difference in back pressure between engines using the Fay valve and those with the ordinary valve. The general dimensions of the engine were:

Diameter of cylinder	18 in.
Stroke of piston	22 in.
Diameter of driving-wheels	68½ in.
Total weight of engine	90,800 lbs.
Steam-ports	14½ in. × 1 in.
Exhaust-ports	14½ in. × 2¼ in.
Valve travel	4¾ in.
Outside lap	¾ in.
Inside lap	0 in.
Working pressure	160 lbs.

On February 7 the test was with the Fay valve, the mean temperature 34° F., and the wind southwest, blowing from 15 to 20 miles per hour. The rails were frosty and the train consisted of one baggage-car, one smoking-car, two passenger coaches, and two 12-wheeled drawing-room coaches. Weight of engine and tender loaded, 80 tons. Estimated weight of train, 248 tons.

On February 8, with a temperature of 41° F. and the same wind, the ordinary valve was tried. The rails were wet (rain during the night of the 7th), and the train consisted of one baggage-car, one smoking-car, two passenger coaches, and two eight-wheeled drawing-room coaches. Estimated weight of train, 250 tons.

The train each day was the regular New York express (schedule train No. 63), leaving Boston at 9 A.M.; due at Springfield at 11.50 A.M.

The indicator was applied to the left-hand cylinder only, using a Crosby three-way cock with ¼ in. pipe connections. During the tests every effort was made to permit the taking of duplicate indicator cards. All engine data (speed, boiler pressure, and cut-off) was taken to Mr. T. Purvis, Jr., Division Master Mechanic of the Boston & Albany Railroad, and as a result of his efforts and of the skill of the engineer of engine No. 173, the sets of diagrams shown in the table were produced under nearly the same conditions.

During the night of the 7th the steam-chest cover of the left-hand cylinder was removed and the four extra cylinder ports, each ¾ in. in diameter, were screw-plugged, thereby making the left-hand cylinder the same as it was before the application of the Fay valve. In each test the same valve was used, without change, on the left-hand cylinder.

It is claimed that a comparison of the indicator cards given in the accompanying engraving shows the counter pressure to have been increased 29.2 per cent., or the average compression, including preadmission, was increased 24.2 per cent.,

and the average back pressure increased 38 per cent. with the ordinary valve over the Fay valve, this taking the atmospheric line as a base.

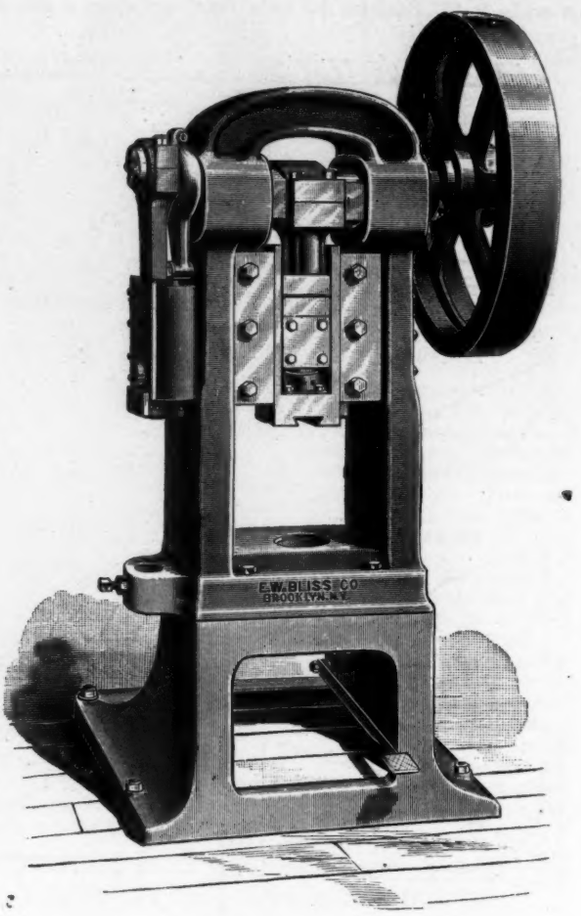
TRIMMING PRESS FOR DROP FORGINGS.

THIS cut represents a press of late design brought out by the E. W. Bliss Company, and it is intended for use in the forge shop where hot metal is to be trimmed. It was the intention of the designers to build a press that would meet as nearly as possible all the requirements for which a press of this class of work can be used. The press is fitted with the well-known Bliss clutch and a patented adjustment in the slide, and has a supplementary slide in the side of its frame to be used in cutting off the work from the bar after it is forged and trimmed. This is considered a new feature in a press of this kind, and will be at once appreciated by persons using such machines. The construction of the machine is very strong, and every detail has been carefully studied. These presses are built in several sizes and are usually made with fly-wheels, as forgings are usually required to be trimmed very quickly and a high-speed machine becomes necessary. This cut represents a press which has a 4-in. stroke, 4-in. adjustment, and is 15 in. from bed to end of slide when up; distance between uprights is 22 in. This machine carries a 908-lb. fly-wheel, the total weight being 5,500 lbs. The dimensions can be modified to suit special requirements if it is necessary. These presses can also be geared for cold trimming.

A SOLID ROCK DREDGER.

THE great increase in size and draft of steamships of late years has rendered it necessary to deepen and otherwise enlarge the channels leading to many of the great harbors and docks of the world. In a number of instances the much-needed work has been delayed because, the entrance-way being formed through rock, the enlargement has had to be effected by the slow and costly process of first loosening the rock by blasting and afterward dredging up the spoil, the difficulties being greatly increased when the entrance was situated in an open sea-way. The tendency of recent practice has, therefore, been to construct the dredger of such strength and power as to enable it to cut its way through the solid rock without the preliminary operation of blasting. The latest instance of this method of procedure is afforded by the new channel leading to the harbor of Alexandria, which had to be excavated for a width of 300 ft. through a series of ridges of solid rock extending for about a mile in an open sea-way. The prevalence of a heavy swell greatly added to the difficulties of the work, which, however, was accomplished practically without the use of explosives, and constitutes a unique example of rock-dredging. The work was executed by Messrs. S. Pearson & Son, of Westminster, who afterward disposed of the dredger to the Government. Having, however, taken a contract for excavating a channel through the rock at Bermuda for the Colonial Government, the firm have had a new and very powerful steam dredger designed, which embodies various improvements suggested by their experience at Alexandria and elsewhere.

This is an 800-ton hopper dredger, and is being built and engined by Messrs. Lobnitz & Co., of Renfrew, at whose works we recently inspected the vessel. She is 208 ft. long over all, with a breadth of 40 ft., a depth of 17 ft. 3 in., and a displacement when loaded of 2,200 tons. She is entirely steel built, and will be capable of steaming to any part of the world at a speed of 7 knots. She will be propelled by twin screws, driven by independent triple-expansion engines of 800 H.P. The dredging-gear, ladder, and bucket chain are probably the strongest ever made; they are of steel and weigh together about 100 tons. The bucket chain will be driven by an independent compound surface-condensing engine of special construction with 16-in. and 30-in. cylinders respectively and a 2-ft. stroke, and working at 100 lbs. pressure. Steam for the engines will be provided by two cylindrical steel boilers of the return tubular type of 1,000 H.P. combined. They are arranged independently, so that one can be cleaned out while the other is in use for dredging. For ordinary service the vessel will carry 100 tons of coal, while for long voyages she can take in 600 tons. All the dredging-gear will have such an excess of strength that it will pull up the engine if any impediment is met with in working, and a breakdown will thus be avoided. The bucket ladder is fitted with 10 powerful buffer springs, which will cushion any shocks that may be experienced when the dredger is working in a sea-swell. By an



TRIMMING PRESS FOR DROP FORGINGS.

interchange of wheels dredging can be affected at three different speeds, to suit the degree of hardness of the materials met with. The vessel will dredge to a depth of 45 ft. below water level, and she will be able to cut "her own flotation"—that is, she will cut her way through a bank above water level. The dredged material will be delivered by the buckets through shoots into steel hoppers on either side of the vessel, each of which is capable of containing 7,000 cub. ft. of spoil, or it may be delivered into barges alongside, by altering the shoots. The vessel will also carry a special rock cutter for use in cases where the rock may prove exceptionally hard. She is likewise arranged for dredging in soft ground, and when cutting a channel such as a canal she will deliver the dredged materials on to the shore on either side.

The dredger is fitted with steam-steering gear, which can be worked from both of her bridges. A titan steam crane will be mounted on deck for moving any of the heavy parts for examination or repair, and there will be a set of artificers' shops, so that all ordinary and even heavy repairs can be executed on board. The vessel will be lighted throughout by electricity, and will carry a search-light. Ample accommodation is provided for the officers and crew, and, in addition to the usual boat equipment, she will carry a large steam launch as a tender. This dredger, which is the strongest and most powerful ever constructed, is being built to Lloyd's and the Board of Trade requirements as a sea going vessel, and will be launched about the beginning of February.—*London Times.*